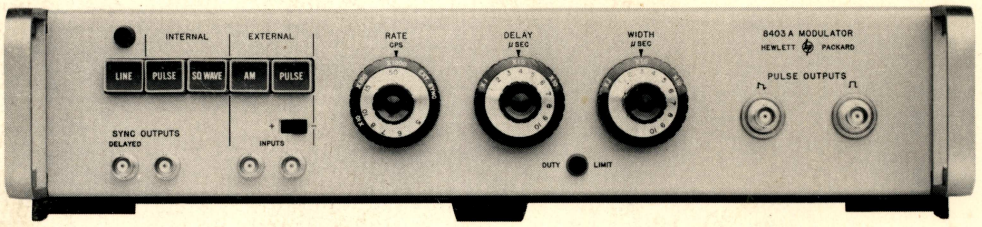
OPERATING AND SERVICE MANUAL

# MODULATOR

## 8403A




HEWLETT hp PACKARD

HP-8403A

## CERTIFICATION

*The Hewlett-Packard Company certifies that this instrument met its published specifications at the time of shipment from the factory. Hewlett-Packard Company further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.*

## WARRANTY AND ASSISTANCE

This Hewlett-Packard product is warranted against defects in materials and workmanship for a period of one year from the date of shipment. Hewlett-Packard will, at its option, repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard, and provided the preventive maintenance procedures in the manual are followed. Repairs necessitated by misuse of the product are not covered by this warranty. NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. HEWLETT-PACKARD IS NOT LIABLE FOR CONSEQUENTIAL DAMAGES.

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# MODULATOR
# 8403A

### SERIALS PREFIXED: 1150A

This Operating and Service Manual applies to HP 8403A instrument with serial number prefix 1150A.

### SERIAL PREFIXES NOT LISTED

For instruments with serial number prefixes below 1150A, a "Backdating Appendix" sheet is supplied in the back of this manual.

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HEWLETT hp PACKARD

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Table 1-1. Specifications

## OUTPUT CHARACTERISTICS

AM and pulse output for driving 8730 PIN Modulators. Pulse output specially shaped for optimum RF rise and decay times.

Pulse output for general pulse applications: positive dc-coupled 25 to 30V in amplitude, approximately symmetrical about 0V; no AM signal.

Output signals available concurrently from separate front-panel connectors.

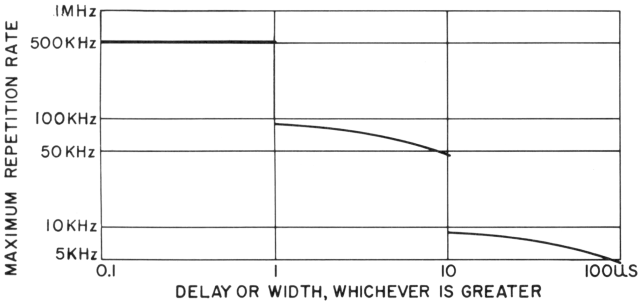
## INTERNAL MODULATION

### SQUARE WAVE

Frequency: Continuously variable from 50 Hz to 50 KHz, 3 decade ranges
Symmetry: Better than 45/55%

### PULSE

Repetition Rate: Continuously variable from 50 Hz to 50 KHz, 3 decade ranges
Delay: Continuously variable from 0.1 μsec to 100 μsec, in 3 decade ranges between sync out pulse and RF output pulse
Width: Continuously variable from 0.1 μsec to 100 μsec in 3 decade ranges
Maximum duty cycle: See graph




### EXTERNAL SYNC

Amplitude: 5 to 15V peak
Waveform: Pulse or sine wave
Polarity: Either positive or negative
Input Impedance: Approx 2000Ω, dc coupled
Rate: Subject to internal recovery time considerations; see graph

### TRIGGER OUT

Sync Out: 0.1 to 100 μsec in advance of output pulse, as set by DELAY control (for internal pulse operation) and Simultaneous with output pulse (for square wave and external pulse operation).
Delayed Sync Out: Simultaneous with output pulse for internal pulse operation; No output in other modes of operation.
Amplitude: Approximately -2.0V
Source Impedance: Approximately 330Ω

## EXTERNAL MODULATION

### PULSE INPUT

Amplitude and Polarity: 5 to 15V peak, either positive or negative
Repetition Rate: Maximum average prf, 500 KHz/sec
Input Impedance: Approx 2000 ohms, dc coupled
Minimum Width: 0.1 μsec
Maximum Width: $\frac{1}{\text{prf}}$ - 0.4 μsec

### CONTINUOUS AMPLITUDE MODULATION

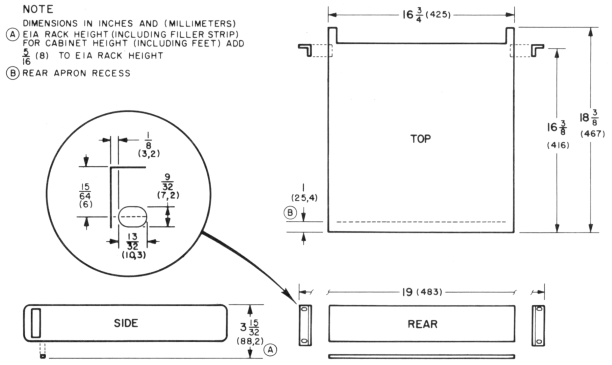
Maximum Frequency: 10 MHz, sinusoidal
Sensitivity: Approximately 10 dB/V with HP 8730A series, approximately 20 dB/V with HP 8730B series
Input Impedance: Approximately 1000Ω
Level Control: AM input is dc coupled, permitting control by bias of AM input; rear panel control for use with ac coupled modulation.

## GENERAL

### POWER REQUIREMENTS

115 or 230V ±10%, 50 to 1000 Hz, approx 10 W

### DIMENSIONS




WEIGHT - Net 14-1/2 lb (6, 5 kg)

### OPTIONS

001. HP Model 8731A PIN Modulator installed
002. HP Model 8731B PIN Modulator installed
003. HP Model 8732A PIN Modulator installed
004. HP Model 8732B PIN Modulator installed
005. HP Model 8733A PIN Modulator installed
006. HP Model 8733B PIN Modulator installed
007. HP Model 8734A PIN Modulator installed
008. HP Model 8734B PIN Modulator installed

# SECTION I
# GENERAL INFORMATION

## 1-1. INTRODUCTION.

1-2. The Hewlett-Packard Model 8403A Modulator (Figure 1-1) is a dual function modulation unit that can be used to provide two simultaneous modulation output signals. One modulation output provides pulse and square-wave modulation signals for general applications, such as modulating an RF signal generator. The other modulation output provides specially shaped modulating signals for modulating the HP Model 8730 series of PIN Modulators. Internally generated pulse and square-wave modulating signals, which are adjustable in rate from 50 Hz to 50 KHz, are available at either modulation output. In addition, externally applied pulse- and amplitude-modulation signals may be applied to the Model 8403A. However, amplitude modulation signals will only be available at the modulation output for use with PIN Modulators, while the externally applied pulse modulation signals are available at both outputs.

1-3. For internally generated pulse modes of operation (internally or externally synchronized) synchronizing and delayed synchronizing pulse outputs are available. In all other modes of operation, except AM where no sync output is available, only a synchronizing output which is coincident with the leading edge of the modulating output signal is available. A complete listing of the operating specifications for the Model 8403A is given in Table 1-1.

## 1-4. SUPPLEMENTARY INSTRUMENTS.

1-5. A series of instruments capable of extending the operating parameters of the Modulator are the Hewlett-Packard 8730 series of PIN Modulators (refer to Appendix). With a PIN modulator, the Model 8403A can be used to pulse with 30- to 40-nanosecond rise and decay time characteristics, level, or amplitude modulate with sinusoidal and complex waveforms. In addition, with a PIN modulator leveling and amplitude modulation of RF signals can be accomplished simultaneously.

## 1-6. INSTRUMENT OPTIONS.

1-7. Options 001 through 009.General purpose pulse output connector mounted on rear panel; a PIN Modulator installed with RF input and output connectors protruding from front panel in the place normally occupied by the pulse output connectors. Note that since the specially shaped output is used to modulate a PIN Modulator and since the PIN Modulator is mounted internally, this output is connected to the PIN Modulator internally and not brought out to either the front or rear panel. In all other respects, operation of this instrument is the same as for the standard instrument and the information in this manual applies directly (see Table 1-1 for listed options). See Appendix II at the rear of this manual for complete description.

## 1-8. INSTRUMENT IDENTIFICATION.

1-9. Hewlett-Packard uses a two-section, eight-digit serial number (on instrument rear panel) to identify instruments (000-00000). The first three digits are a serial prefix number, and the last five digits refer to a specific instrument. If the serial prefix on your instrument does not appear on the title page of this manual, there are differences between the manual and your instrument which are described in the Appendix or in a Manual Change Sheet included with the manual. If the change sheet is missing, the information can be supplied by your local sales office.

Figure 1-1. Model 8403A Modulator

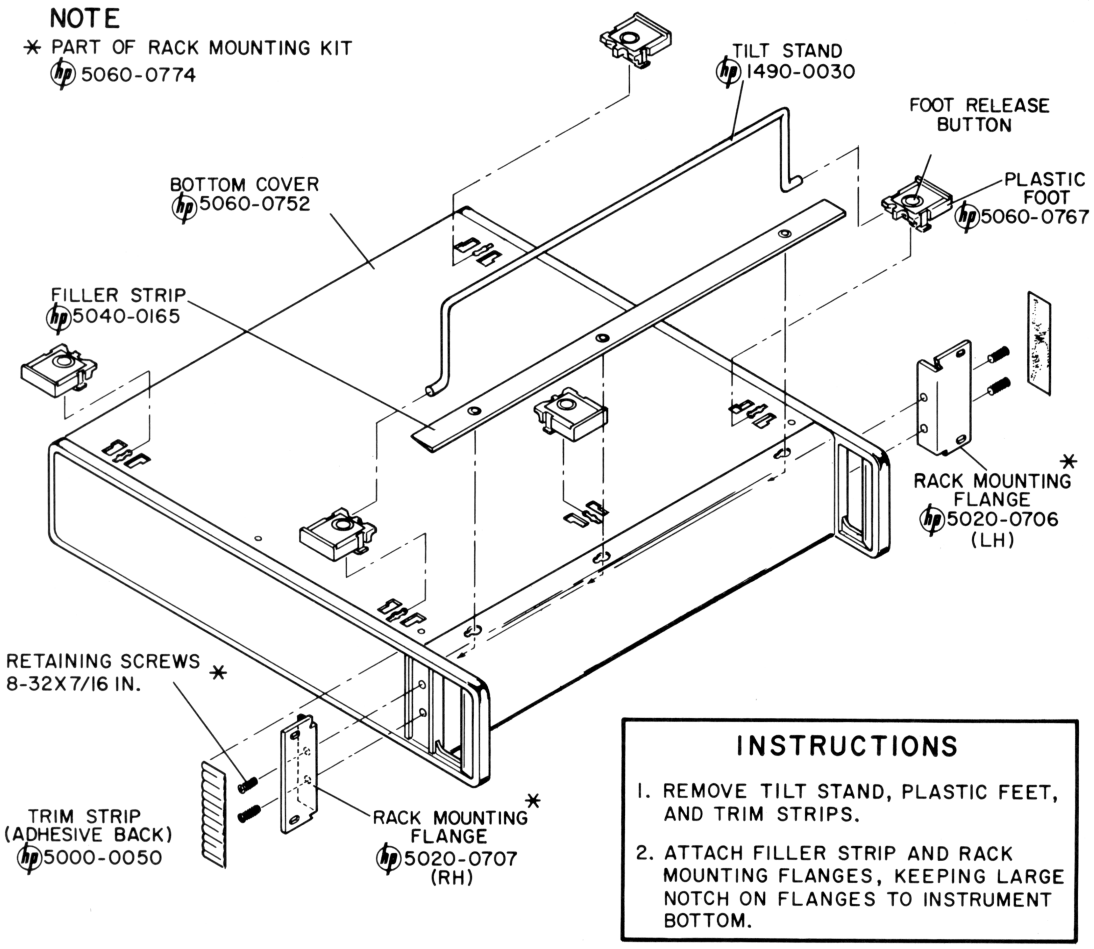



Figure 2-1. Conversion to Rack Mount

# SECTION II
# INSTALLATION

## 2-1. INCOMING INSPECTION.

2-2. This instrument was inspected, both mechanically and electrically, before shipment. To confirm this, the instrument should be inspected for physical damage in transit. Also test the electrical performance of the instrument, using the procedure given in paragraph 5-3. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

## 2-3. INSTALLATION.

2-4. The Model 8403A is of modular design and is shipped as a cabinet mount instrument. A kit is supplied with the instrument for conversion from cabinet to rack mount.

2-5. Whether the instrument is cabinet- or rack-mounted, provisions should be made to insure that there is adequate air circulation around the instrument. When installing the instrument, see that the ambient temperature does not exceed 55°C (131°F).

2-6. CONVERSION TO RACK MOUNT.

a. Remove trim strip on sides of instrument (see Figure 2-1).

b. Remove tilt stand by pressing two sides of stand toward center of instrument and lifting it out.

c. Remove the five feet at bottom of instrument (press button in center of each foot, slide foot forward toward center of instrument, and lift it out).

d. Place rack mounting flanges (two) where trim strips were and secure with screws provided.

e. Add filler strip to bottom of instrument.

2-7. POWER REQUIREMENTS.

2-8. The Model 8403A can be operated from either 115 or 230 volts, 50 to 1000 Hz source. A slide switch (LINE VOLTAGE S2) located on rear panel, converts the instrument for operation from 115 or 230 volts. A 1/4 ampere slo-blo fuse is used for 115 volt operation; a 1/8 ampere slo-blo fuse is used for 230 volt operation.

**CAUTION**

NEVER SWITCH LINE VOLTAGE SWITCH FROM ONE PRIMARY POWER POSITION TO THE OTHER WHEN INSTRUMENT IS IN OPERATION.

2-9. POWER CABLE.

2-10. To protect operating personnel, the National Electrical Manufacturer's Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground pin.

2-11. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

## 2-12. REPACKAGING FOR SHIPMENT.

2-13. The following is a general guide for repackaging an instrument for shipment. If you have any questions, contact your local Hewlett-Packard sales and service office.

a. If possible, use the original container designed for the instrument. Note: Carton, etc., can be ordered if desired.

b. Wrap instrument in heavy paper or plastic before placing it in shipping container.

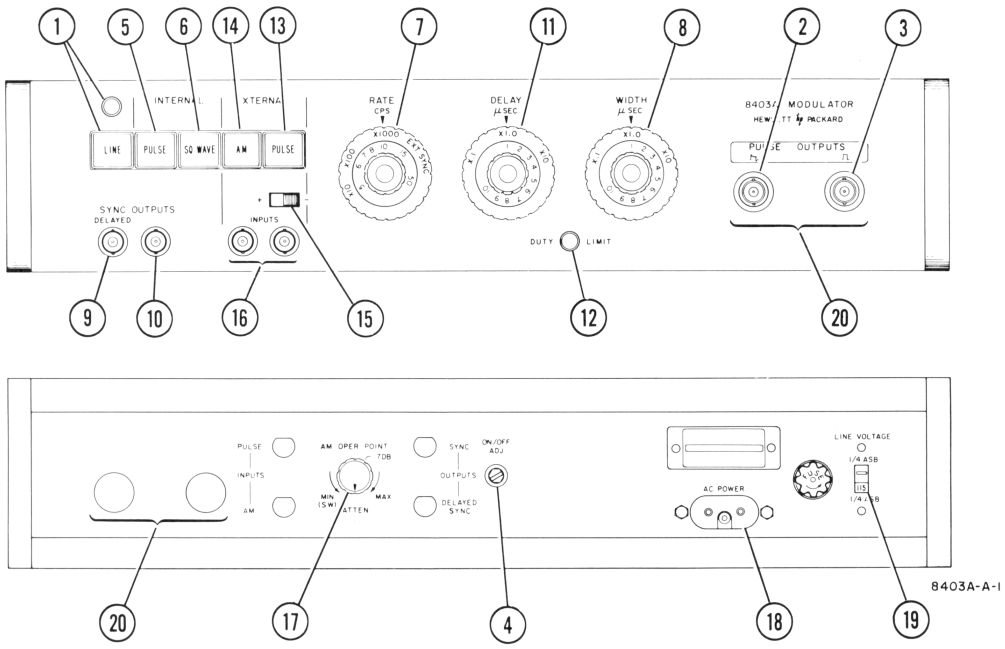
c. Use plenty of packing material around all sides of instrument and protect panel faces with cardboard strips.

d. Use a heavy cardboard carton or wooden box to house the instrument, and use heavy tape or metal bands to seal the container. Bind all carton joints and seams with heavy paper tape.

e. Mark the packing box "FRAGILE - DELICATE INSTRUMENT", etc. as appropriate.

Note

If the instrument is to be shipped for service or repair, attach to the instrument a tag identifying the owner, model number, full serial number, and indicating the service or repair to be accomplished.




1. LINE. Depressing completes primary power circuit; lamp glows.
2. Special output. Provides specially shaped current signals for driving hp Model 8730-series PIN Modulators.
3. General Purpose Output. For general purpose pulse and square-wave rectangular outputs. No output in AM mode of operation.
4. ON/OFF ADJ. Sets DC current level of special output (item 2 above).
5. INTERNAL PULSE. Sets instrument for internal pulse operation.
6. INTERNAL SQ WAVE. Sets instrument for internal square wave operation.
7. RATE CPS. For internal pulse or square-wave operation only, sets repetition rate. EXT SYNC position allows external synchronization of internal pulse rate.
8. WIDTH μSEC. Sets pulse output signal width: Operative for internal pulse operation only.
9. DELAYED Sync Output. Reference output pulse coincident with leading edge of pulse output signal. Output available for internal pulse operation only.
10. Sync Output. Reference pulse output: undelayed output in advance of pulse output signals (internal pulse operation only); coincident with the leading edge of pulse output signal (square-wave and external pulse operation only).
11. DELAY μSEC. Sets delay between sync output signal and pulse output signal: Operative for internal pulse operation only.
12. DUTY LIMIT. Lamp flashes when duty limit cycle of instrument is exceeded: Operative for internal pulse operation only.
13. EXTERNAL PULSE. Sets instrument for external pulse operation.
14. EXTERNAL AM. Sets instrument for external AM operation.
15. Polarity Switch. Sets instrument to accept either negative or positive pulse signals.
16. INPUTS. Input beneath AM button accepts signals when AM button depressed: Input beneath EXTERNAL PULSE button accepts signals when EXTERNAL PULSE button is depressed or INTERNAL PULSE button is depressed for EXT SYNC.
17. AM OPER POINT. For AM operation only, sets reference level about which AM signal is superimposed.
18. AC POWER. Power cable receptacle.
19. LINE VOLTAGE. Sets instrument to operate with 115- or 230-Vac line; insert narrow blade and slide up for 115V, slide down for 230V.
20. OPTION 001 through 009. HP Model 8730-series PIN Modulator installed internally (see Table 1-1): PULSE OUTPUTS connectors replaced with PIN Modulator RF input and output connectors (female type N); General purpose output (Item 3 above) mounted on rear panel.

Figure 3-1. Controls and Indicators

# SECTION III
# OPERATION

## 3-1. INTRODUCTION.

3-2. The Model 8403A Modulator is a dual output modulation source providing internal pulse and square-wave modes of operation with rates variable from 50 to 50,000 Hz. In addition, external amplitude and pulse modes are also available: in the external pulse mode, pulse rates as great as 1 MHz average and 2 MHz/sec peak can be used; in the external AM mode, the 8403A becomes a single output source providing specially shaped signals for driving hp Model 8730-series PIN Modulators. Pushbutton controls select the mode of operation. Input connectors, for AM or pulse operation, are located directly beneath the push-button to which they apply.

## 3-3. CONTROLS AND INDICATORS.

3-4. Functions of all front and rear panel controls and indicators are given in Figure 3-1. The function of each control and indicator is keyed to the illustration of the instrument front and rear panels which appears in Figure 3-1.

## 3-5. BASIC OPERATING PROCEDURE.

3-6. TURN-ON.

a. Set rear-panel 115-230 LINE VOLTAGE switch to match line voltage.

b. Release any front panel buttons that may be depressed.

c. Connect Modulator to power source.

d. Depress front-panel LINE button. The line indicator lamp (located directly above the LINE button) should glow indicating line power applied to instrument. Failure of indicator to glow is an indication of a bad indicator lamp, lack of line voltage, or trouble within the instrument.

3-7. ON/OFF ADJ.

3-8. When an hp Model 8731/32/33/34 or 8735 PIN Modulator is used with the 8403A, the preliminary operating adjustment detailed below must be made. Note: This adjustment should be for any individual PIN Modulator used with the 8403A.

a. Connect equipment as shown in Figure 3-2.

b. Set 8403A as follows:
LINE . . . . . depressed
EXTERNAL PULSE . . . . . depressed

c. Note rated current value stamped on label on underside of PIN Modulator. Adjust 8403A rear panel ON/OFF ADJ adjustment for a DC Ammeter reading equal to rated current value.

d. The 8403A Modulator is now adjusted to provide one specific PIN Modulator with optimum operating currents.

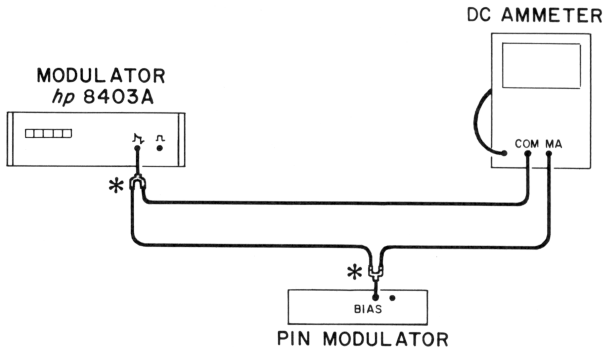



Figure 3-2. On/Off Ratio Adjustment

3-9. MODULATION SIGNAL DISTORTION.

3-10. Cable connections between the 8403A Modulator PULSE OUTPUTS and a PIN Modulator or other driven equipment should always be as short as possible to avoid modulation distortion caused by excessive cable length capacity.

CAUTION

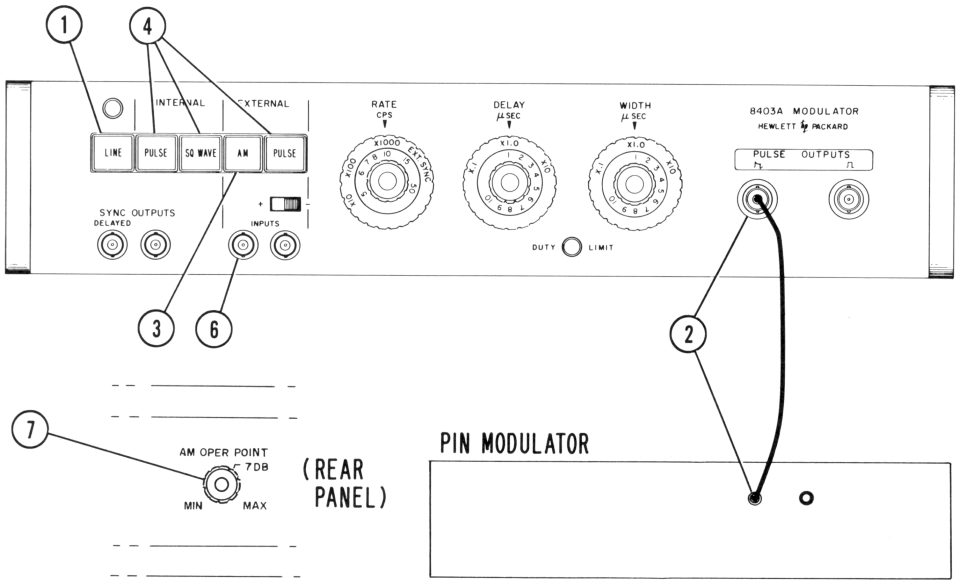
Do not apply external shorts to either of the General Pulse Outputs, to do so could cause damage to transistors Q603 and Q605.

## 3-11. MODULATION FUNCTIONS.

3-12. The Modulator has four modulation functions which are designated Internal Pulse, Internal Square-Wave, External AM, and External Pulse. Four separate pushbuttons, each labeled for the function it selects, determine the type of modulation-operation. The Modulator will not operate properly if more than one modulation function button is depressed at the same time.

3-13. INTERNAL PULSE FUNCTION.

3-14. For the internal pulse function, rate is adjustable from 50 Hz to 50 KHz and width is adjusted from 0.1 to 100 microseconds. In addition, two synchronized pulse outputs are available: one is the DELAYED SYNC OUTPUT, a -2 volt pulse which is coincident with the leading edge of the pulse output signals; the other is the SYNC OUTPUT, a -2 volt pulse which is undelayed or leads the pulse output signals from 0.1 to 100 microseconds depending upon the front panel DELAY μSEC control setting. Depressing the INTERNAL PULSE button selects mode of operation, RATE CPS control selects pulse repetition rate, and WIDTH μSEC control selects pulse width. The DELAY μSEC control selects delay between undelayed sync output (available at connector directly beneath INTERNAL PULSE button) and DELAYED sync output.




1. LINE depressed.
2. Connect Special output to PIN Modulator BIAS output.
3. Depress AM button.
4. Release AM button by depressing any other function and then depress AM button again.

**CAUTION**

Do not apply RF power in excess of 1 watt (peak or CW) to PIN Modulator.

5. Apply unmodulated RF power to either PIN Modulator end port.
6. Apply AM signal to AM INPUT.
7. Using the rear panel AM OPER POINT control, observe modulated RF output from PIN Modulator with an Oscilloscope and adjust RF attenuation level to avoid peak signal clipping and minimize signal distortion.

Figure 3-3. External AM Operation

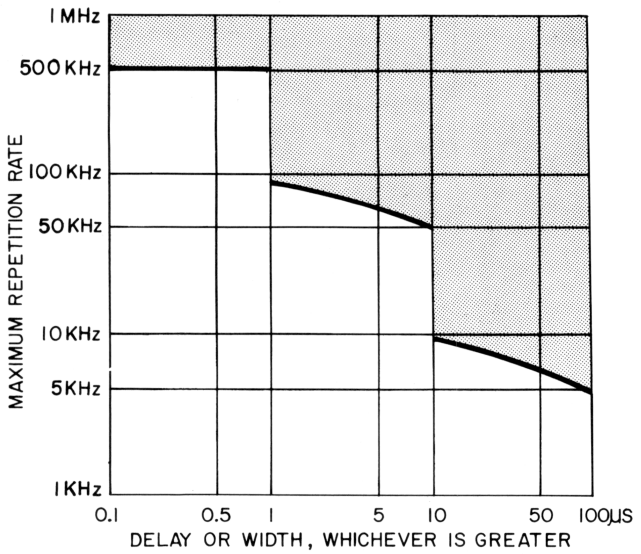



Figure 3-4. Duty-Cycle Limit Graph

Note

When delay-rate-width combination exceeds duty limit of instrument, the DUTY LIMIT lamp flashes. Duty-cycle limit is exceeded when RATE multiplier is X1000 and DELAY and/or WIDTH multiplier are at 10 (see Figure 3-4).

3-15. INTERNAL PULSE/EXTERNAL SYNC FUNCTION.

3-16. The internal pulse/external sync function consists of an externally applied pulse or AM signal whose leading edge determines the pulse repetition rate of the pulse output signals and the two sync output signals. The externally applied synchronizing signal is applied at the INPUT connector located directly beneath EXTERNAL PULSE button. This external synchronizing function is selected by setting the RATE CPS control to the EXT SYNC position and depressing the INTERNAL PULSE button. The EXTERNAL PULSE is not depressed. Pulse width and delay is adjusted as described for INTERNAL PULSE operation above.

Note

DUTY LIMIT lamp is inoperative when rate is externally controlled. Refer to Figure 3-4 for duty-cycle-limits.

3-17. INTERNAL SQ WAVE FUNCTION.

3-18. For internal square-wave function, rate is adjustable from 50 Hz to 50 KHz and a synchronizing pulse signal which is coincident with the leading edge of the square-wave signal is available at the SYNC output connector located directly beneath the INTERNAL PULSE button. Depressing the INTERNAL SQ WAVE button selects mode of operation, and the RATE CPS control selects modulating signal frequency rate. No undelayed or leading sync output signal is available and the WIDTH µSEC and DELAY µSEC controls are inoperative.

3-19. EXTERNAL PULSE FUNCTION.

3-20. For external pulse function, the rate is dependent upon the externally applied pulse rate and may be as great as 1 MHz, average, and 2 MHz peak. Pulse width is dependent upon the width and rate of the externally applied pulse signal and is limited to a minimum of 0.1 microsecond and a maximum of $\frac{1}{\text{prf}}$ minus 0.4 microseconds. In addition, a -2 volt sync pulse, coincident with the leading edge of the pulse output signals, is available at the sync output connector located directly beneath the INTERNAL PULSE button but, no undelayed or leading sync output is available.

Note

To ensure proper operation, EXTERNAL PULSE button must be depressed, released (by depressing any other function button) and depressed again.

Depressing the EXTERNAL PULSE button selects mode of operation. RATE CPS, WIDTH µSEC, and DELAY µSEC controls are inoperative.

3-21. EXTERNAL AM FUNCTION.

3-22. For the AM function, the 8403A Modulator has only one signal output. This single output is at the special pulse output connector only and is designed for modulating hp Model 8730 series PIN Modulators. The sinusoidal frequency response is 10 MHz. The AM function is selected by depressing the EXTERNAL AM button and a rear panel control allows selection of the DC level upon which the AM signal is to be superimposed (see Figure 3-3).

3-23. LIMITED PEAK PULSE POWER FUNCTION.

3-24. For special applications of the 8403A, when using an hp Model 8730A/B PIN modulator with the 8403A, where peak power level of pulse modulation signals must be limited, it is necessary to modify the 8403A as explained below.

a. Remove capacitor C611 from Duty Limit circuit board (A600).

b. Connect CW signal source to PIN Modulator RF input. Note: Input power to PIN Modulator must not exceed one watt.

c. Connect PIN Modulator BIAS connector to special 8403A pulse output connector.

d. Depress 8403A LINE button.

e. Depress 8403A AM button.

f. Using 8403A rear panel AM OPER POINT control, adjust RF output from 8730 for desired output power level (peak power level).

g. Connect pulse modulating signal to 8403A INPUT located directly beneath the EXTERNAL AM button.

# SECTION IV
# PRINCIPLES OF OPERATION

## 4-1. INTRODUCTION.

4-2. The Model 8403A Modulator consists of five basic sections as indicated in Figure 4-1. These are the control circuits, modulation drive circuit, general pulse circuit, input AM circuit, and power supply. The control circuits set the instrument mode of operation and trigger the modulation drive circuit operation. The modulation drive circuit provides the compensated output signal for driving PIN Modulators and triggers the general pulse circuit which provides rectangular pulse output signals for general use. The input AM circuit adds a DC voltage to an externally-applied AM signal and delivers this combined signal to the modulation drive circuit output. The power supply provides the regulated DC voltages to operate the circuits in the instrument.

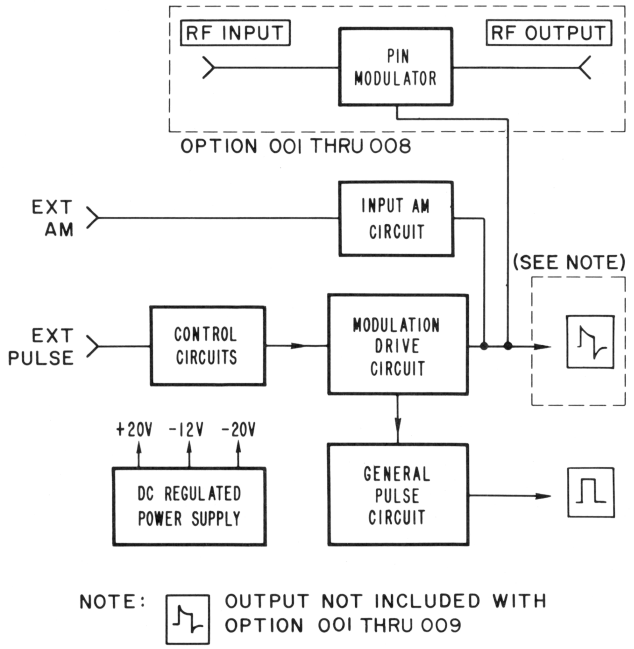



Figure 4-1. Basic Block Diagram

## 4-3. MODULATION OUTPUTS.

4-4. The primary purpose of the 8403A is to provide two simultaneous pulse or square wave modulation output signals: a general purpose rectangular pulse signal and a specially shaped PIN Modulator driving signal. The general purpose rectangular pulse signal is a positive going 25 to 30 volt DC signal which can be used as a modulation or synchronizing signal. The PIN Modulator driving signal is a compensated current-voltage signal for use with the Hewlett-Packard Model 8730-series PIN Modulators (see paragraph 4-5 for a brief description).

## 4-5. PIN MODULATORS.

4-6. The Model 8730-series of PIN Modulators, designed for use with the 8403A, are basically quick-response current-controlled variable-RF attenuators. The types of driving signals used are described below. A complete discussion of the PIN Modulators and their principles of operation is included in the appendix at the rear of this manual.

a. For Pulse and SQ Wave operation: A rectangular pulse signal whose leading and lagging edges are impulsed to provide best rise and decay time characteristics is provided (see Page 5-2, Table 5-3, for a picture of this waveform).

b. For AM operation: The desired AM signal superimposed upon a DC signal level is provided.

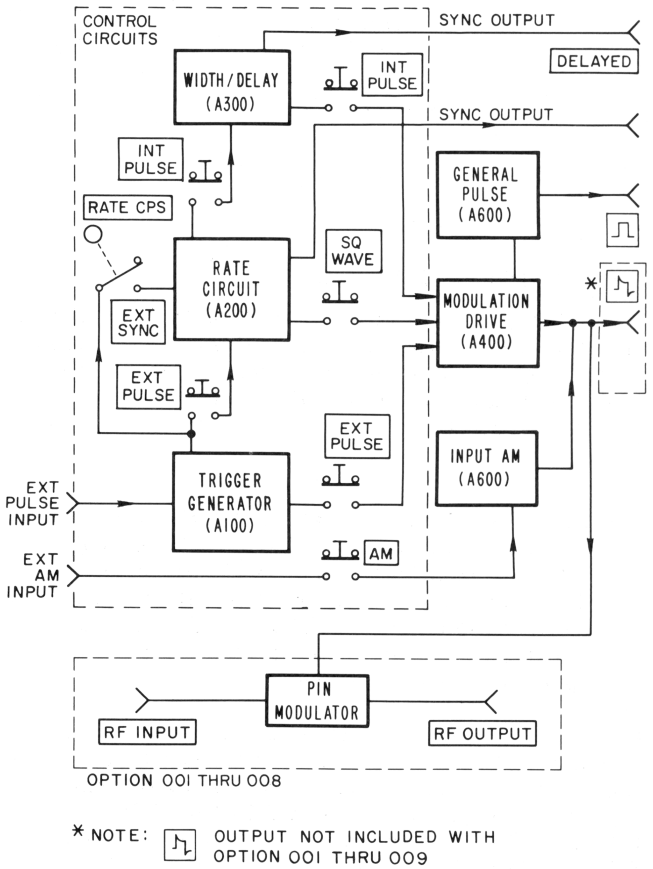



Figure 4-2. Control Circuit Arrangement

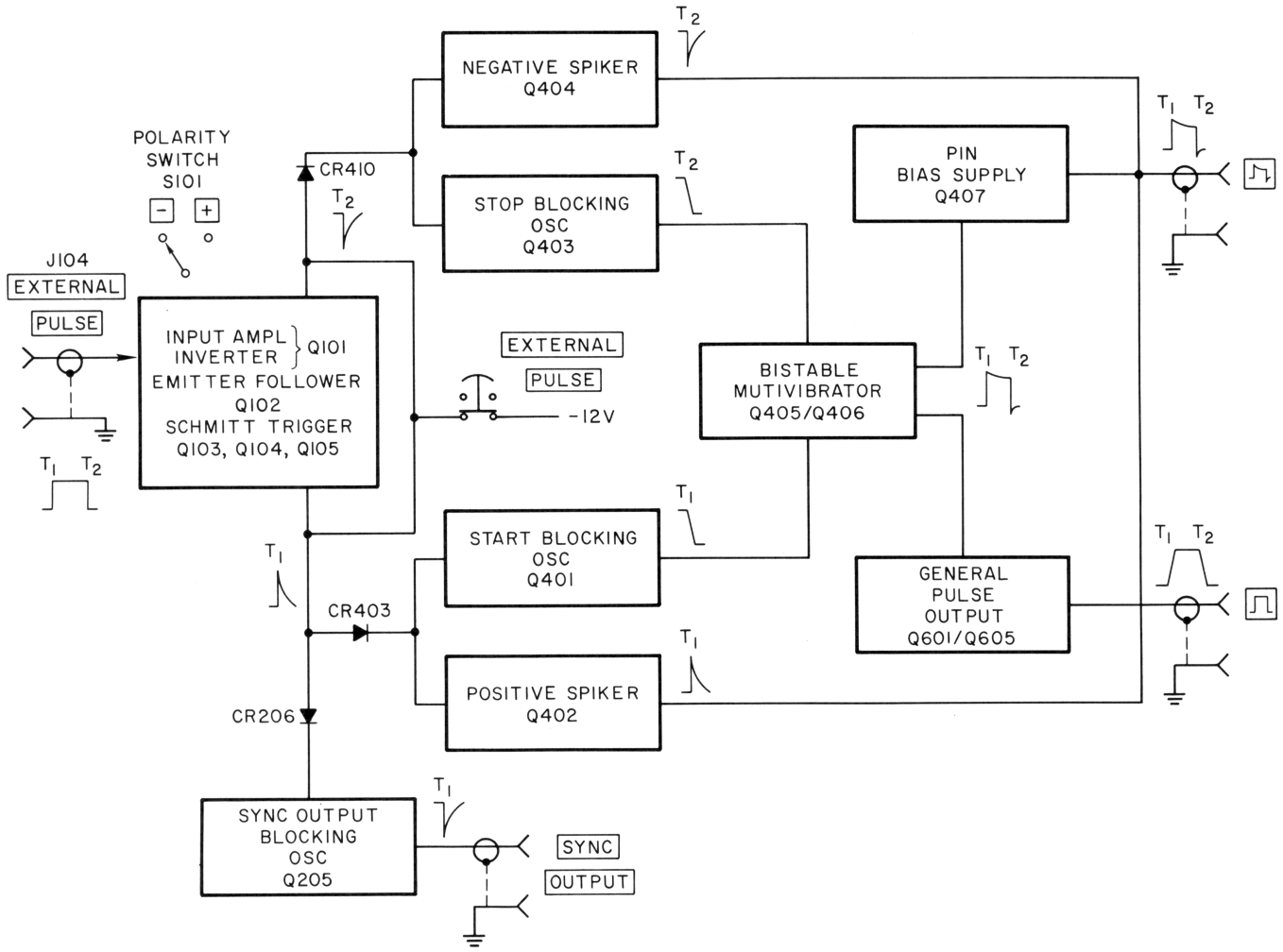



Figure 4-3. External Pulse Operation

## 4-7. CONTROL CIRCUITS.

4-8. The arrangement of the control circuits depends upon the mode of operation. Actual switching from one mode of operation to another is accomplished when the associated panel button or control is operated as indicated in Figure 4-2.

Note

Figure 4-2 illustrates all modulation function buttons released and the RATE CPS control set to any position but EXT SYNC. Hence, from the illustration it can be seen that the modulation drive circuit (A400 assembly) is the only internal circuit common to all modes of operation (excepting Power Supply).

4-9. EXTERNAL AM. External AM circuit is shown in Figure 4-4. With AM button depressed and no AM signal applied, the output signal is approximately +7.4 volts DC providing the AM OPER POINT control is at the MIN position. This +7.4 volts DC biases the PIN Modulator for minimum attenuation. Since the PIN Modulator is a variable-RF attenuator, when biased for minimum attenuation condition only negative going AM signals will be impressed upon the RF signal through the PIN Modulator and all positive-going AM signals will be clipped. To allow positive-going AM signals to be impressed upon the RF signal, the AM OPER POINT control must be used to decrease the +7.4 volt DC level sufficiently to attenuate the RF signal through the PIN Modulator by an amount at least equal to the peak amplitude of the positive-going AM signal.

4-10. With the 8403A set for AM operation, an input AM signal is superimposed upon the set DC level and fed to the PIN Modulator. This AM signal varies the DC bias level to the PIN Modulator and thereby impresses the AM signal upon the RF by varying the attenuation level of the PIN Modulator. The AM frequency response of the 8403A depends upon the RC network of C608 and R607. By increasing the value of C608 the frequency response and input amplitude of the AM signal can be increased; by decreasing the value of C608 the frequency response and input amplitude of the AM signal can be decreased. This C608 value is normally selected for a 10 MHz frequency response.

4-11. EXTERNAL PULSE. A simplified block diagram of external pulse operation is shown in Figure 4-3. With EXTERNAL PULSE button depressed and

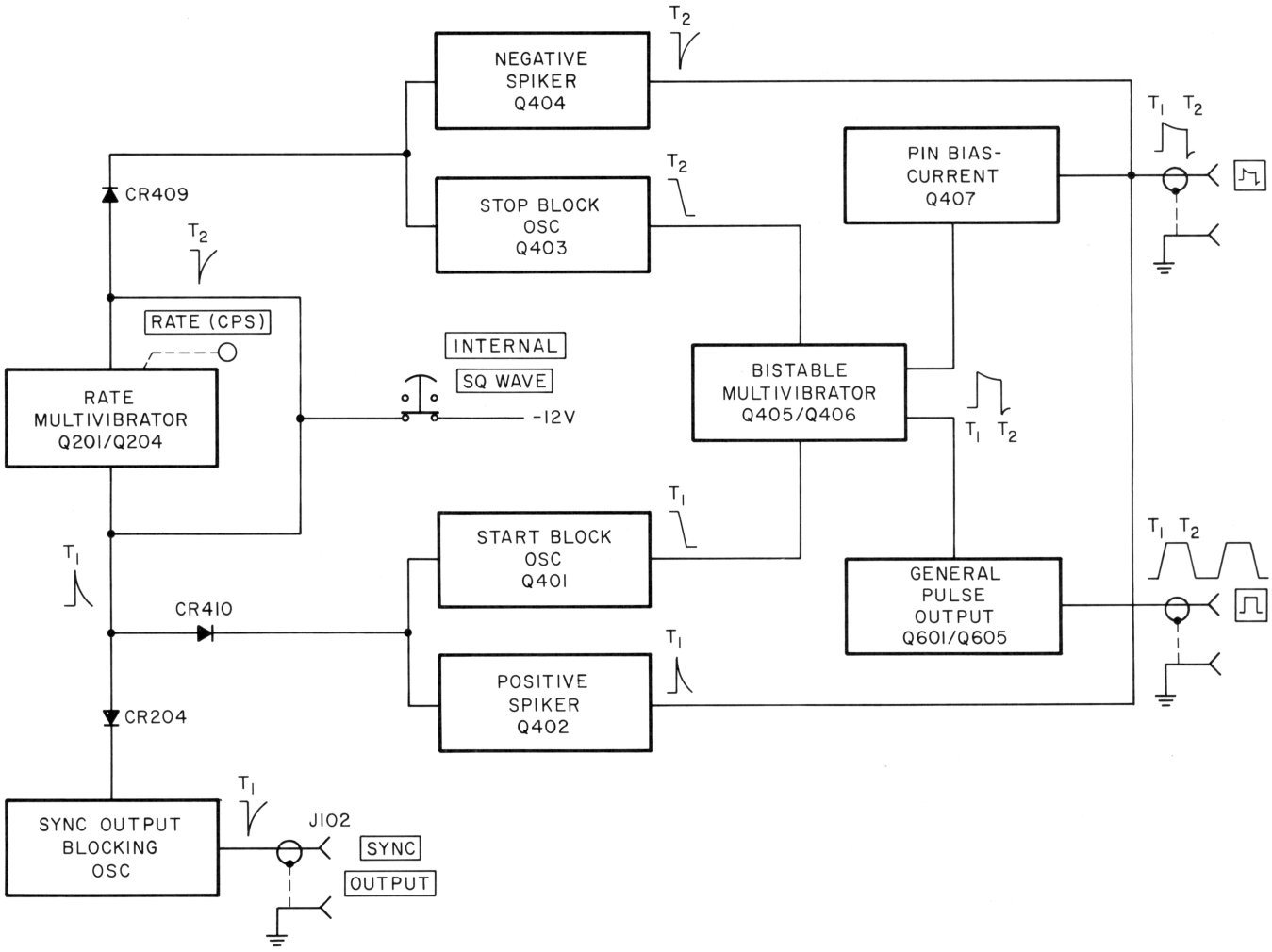



Figure 4-5. Internal Square-Wave Operation

no external pulse signal applied, modulation output conditions are as follows: At the specially shaped PIN Modulator output, approximately -0.8 volt DC signal causing RF signal through PIN Modulator to be attenuated by at least maximum rated attenuation; at general purpose output, approximately -11 volt DC

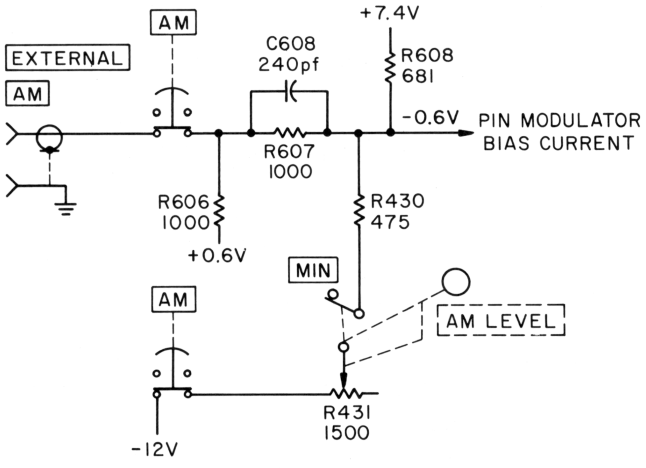



Figure 4-4. External AM Circuit

signal level. The externally-applied pulse is applied through input amplifier Q101 and emitter follower Q102 to the trigger generator (Schmitt triggers Q103/Q104 and Q103/Q105). The Schmitt triggers reshape and differentiate the input pulse and apply it through diode CR206 to sync output blocking oscillator Q205, and through diode CR410 to stop blocking oscillator Q403 and negative spiker Q404, and through diode CR403 to start blocking oscillator Q401 and positive spiker Q402. The start blocking oscillator triggers bistable multivibrator Q405/Q406 off at time $T_1$; the stop blocking oscillator triggers the bistable multivibrator on at time $T_2$. The time interval between $T_1$ and $T_2$ is determined by the width of the externally applied pulse. The positive spiker sends a positive pulse to the PIN Modulator at time $T_1$ to switch the PIN Modulator from a condition of maximum attenuation to a condition of minimum attenuation. Conversely the negative spiker provides a negative pulse to the PIN Modulator at time $T_2$ to switch PIN Modulator back to a condition of maximum attenuation.

4-12. From time $T_1$ to time $T_2$ the pulse from the bistable multivibrator holds the PIN bias supply Q407 off and the general pulse output emitter follower Q604 saturated, resulting in the following output conditions:

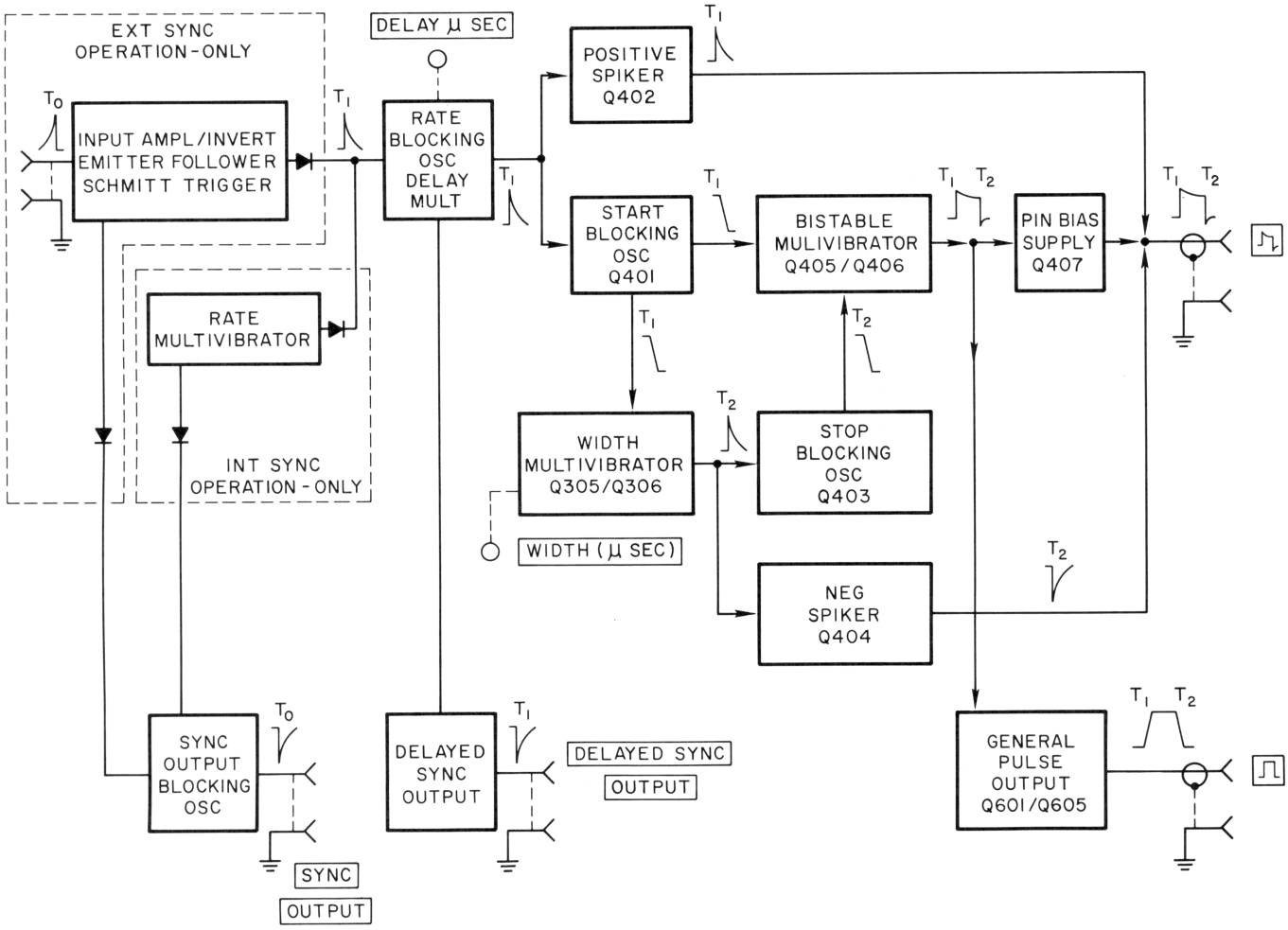



Figure 4-6. Internal Pulse and External Sync Operation

Q407 provides approximately +1 volt DC signal reverse-biasing the PIN Modulator which allows the RF signal to pass through the PIN Modulator with only residual attenuation (minimum insertion loss); Q604 saturated provides approximately +19 volt DC signal at the general pulse output. From time $T_2$ until time $T_1$ recurs, the bistable multivibrator (Q405/Q406) holds Q407 and Q605 on. With Q407 conducting, the proper bias current is supplied to the PIN Modulator to maintain a maximum RF attenuation condition. With Q605 conducting, Q604 is cut off and approximately -11 volts DC is applied to the general pulse output. The waveform present at the specially shaped PIN Modulator output then, is a composite of the signals from the positive and negative spikers and the bistable multivibrator (Q405/Q406). The waveform present at the general pulse output is a composite of the push-pull type operation of Q604 and Q605 in switching the DC output level between approximately one DC supply (+20 volt) and another (-12 volt).

4-13. INTERNAL SQUARE WAVE. A simplified block diagram of internal square-wave operation is shown in Figure 4-5. In this mode of operation the input amplifier, emitter follower, and Schmitt trigger are replaced by rate multivibrator Q201-Q204. The rate multivibrator determines the modulation frequency; the RATE CPS control varies this frequency. The rate multivibrators outputs are differentiated and applied to the start and stop blocking oscillators and sync output blocking oscillator. In all other respects, internal square-wave operation is the same as external pulse operation.

4-14. INTERNAL PULSE AND EXTERNAL SYNC. A simplified block diagram of internal pulse and external sync modes of operation is shown in Figure 4-6. In the internal pulse mode the rate multivibrator is a variable time base generator. It provides an output to the rate blocking oscillator and sync output blocking oscillator. The rate blocking oscillator applies a pulse to the delay multivibrator. The delay multivibrator provides an output at time $T_1$, which follows the pulse at time $T_0$ by a time determined by the DELAY USEC control. This output at time $T_1$ is applied to the delayed sync output blocking oscillator Q304, and start blocking oscillator. The start blocking oscillator applies a pulse to width multivibrator Q305, Q306, and bistable multivibrator at a time equivalent to time $T_1$. The width multivibrator provides a pulse at time $T_2$ that follows the pulse at

time $T_1$ by a time determined by the WIDTH $\mu$ SEC control. The pulse at time $T_2$ is applied to the stop blocking oscillator. From this point on, circuit operation is the same as that given for the external pulse mode, Paragraph 4-11.

4-15. When operating in internal pulse mode of operation with the RATE (CPS) control set to EXT SYNC, operation of the circuit is the same as described above except that the rate multivibrator is replaced by the input amplifier/inverter, emitter follower, and Schmitt trigger. An externally generated signal applied to the pulse input acts as the basic timing pulse (equivalent to time $T_0$).

4-16. EXTERNAL PULSE POLARITY CIRCUIT.

4-17. The external pulse polarity circuit includes Q101 and CR101-CR108. The transistor Q101 operates as a grounded-emitter amplifier when polarity switch S101 is in the (-) position; it operates as a grounded-base amplifier when the polarity switch is in the (+) position.

4-18. NEGATIVE PULSE OPERATION. Refer to the simplified diagram of external negative pulse operation, Figure 4-7. When in the external pulse mode of operation with polarity switch set to (-) position, the external pulse is applied to the base of Q101. Diode CR107 limits input signals to -20 volts; CR103 prevents application of positive signals to the base of Q101. Diode CR104 is an electronic switch that is biased on by the -20 volts applied through polarity switch S101.

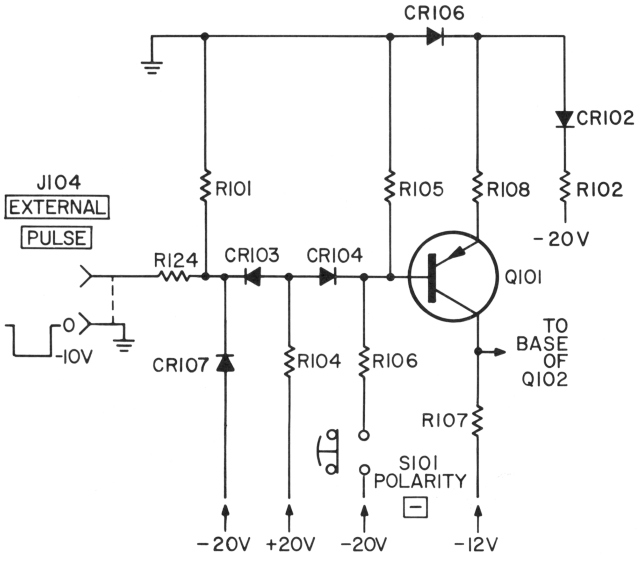



Figure 4-7. Negative Input Pulse Operation

4-19. POSITIVE PULSE OPERATION. Refer to the simplified diagram of external positive pulse operation, Figure 4-8. When in the external pulse mode of operation with polarity switch S101 set to (+) position, the externally-applied pulse is applied to the emitter of Q101. CR108 limits input signals to +20 volts;

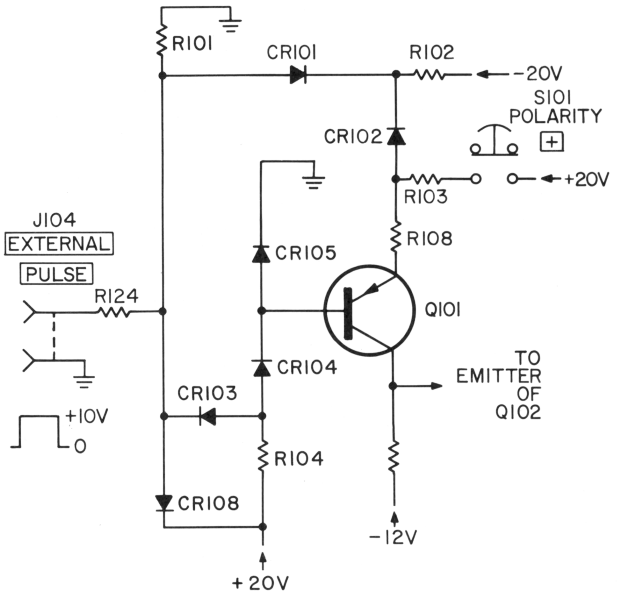



Figure 4-8. Positive Input Pulse Operation

CR101 prevents application of negative signals to the emitter of Q101. Diode CR102 is an electronic switch that is biased on by the +20 volts supplied through polarity switch S101. Diode CR105 clamps the base of Q101 near ground potential.

4-20. RATE MULTIVIBRATOR.

4-21. The rate multivibrator, an astable multivibrator, is used as a variable time base generator in the internal pulse and square-wave modes of operation. Its output frequency is set by the RATE multiplier S201 and RATE vernier R206.

4-22. Refer to Figure 4-9, Rate Multivibrator. The rate multivibrator includes Q201-Q204. Transistors Q201 and Q204 operate as a pair, as do transistors Q202 and Q203. When the circuit is first placed in operation either transistor pair can conduct. Which transistor pair will conduct first, will depend on the characteristics of the transistors and circuit components.

4-23. Consider the instant when C208 is charged and transistor pair Q202 and Q203 go into conduction. The conduction of Q202 charges C205 and places 0 volts at the emitter of Q204, back-biasing it, base-to-emitter. In addition, since C208 is charged to 12 volts and its reference has changed from -12 volts to 0 volts, a +12 volt pulse is applied to Q201 back-biasing it, base-to-emitter. At this time then, transistor pair Q202 and Q203 is forward-biased; transistor pair Q201 and Q204 is back-biased. The circuit will remain in this state until capacitor C208 discharges sufficiently to allow Q201 to become forward-biased. The discharge path for capacitor C208 is R207, R206 (RATE vernier) and Q203 to the -12 volt supply. The conduction of Q201 back-biases Q202 and Q203, base-to-emitter. At this point transistor pair Q201 and Q204 is forward-biased. The circuit will remain in this condition until C205 discharges through R205, R206 (RATE vernier) and Q204 to -12 volts.

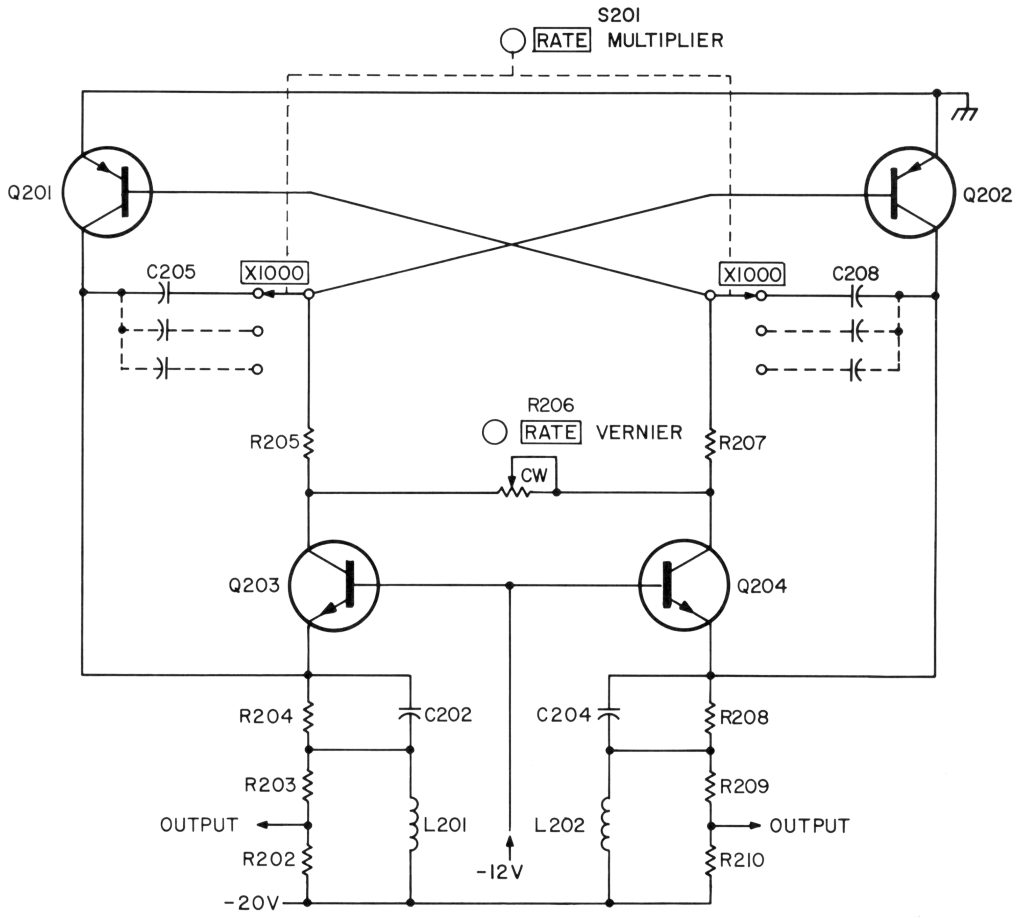



Figure 4-9. Rate Multivibrator

4-24. Rate multivibrator outputs are taken at emitters of Q203 and Q204. The two emitter networks are identical.

4-25. The emitter output, designed to maintain a constant impedance, provides a differentiated output regardless of multivibrator frequency. To accomplish this, the emitter network includes an integrating and differentiating circuit. Normally the differentiated voltage waveform would affect multivibrator operation, but the integrator waveform combines with the differentiated waveform to produce a resultant square-wave voltage at transistor emitter. Thus the desired differentiated output is obtained as is the desired square-wave voltage at the emitter of the transistor.

4-26. THE TRIGGERED BLOCKING OSCILLATOR.

4-27. There are several blocking oscillators in the Model 8403A. The prime function of each oscillator is to provide triggering pulses with a fast rise time thus minimizing modulating-pulse jitter. Since the blocking oscillators used in the instrument are all basically the same, the rate blocking oscillator has been chosen for discussion.

4-28. Refer to Figure 4-10, Rate Blocking Oscillator. The triggered blocking oscillator transistor Q301 does not conduct until a pulse is applied. A transformer T301 connected between base and collector of Q301 provides regenerative feedback to the circuit.

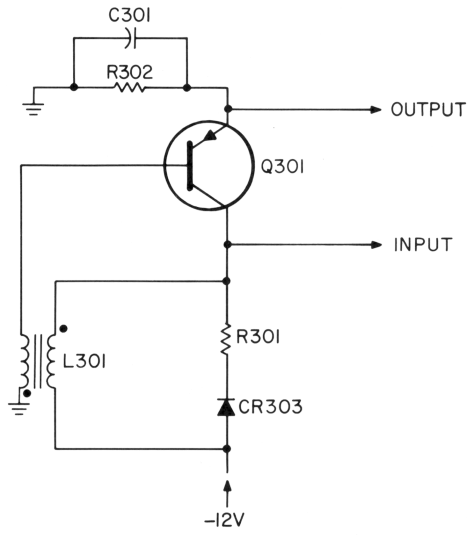



Figure 4-10. Rate Blocking Oscillator

4-29. When the blocking oscillator is triggered into conduction it provides regenerative feedback from collector to base of Q301 through transformer T301. Once Q301 saturates, lines of force built up in the windings of the transformer collapse, which in turn return the circuit to its quiescent state. Thus, once the circuit is triggered it quickly goes through its cycle due to the effects of regenerative feedback.

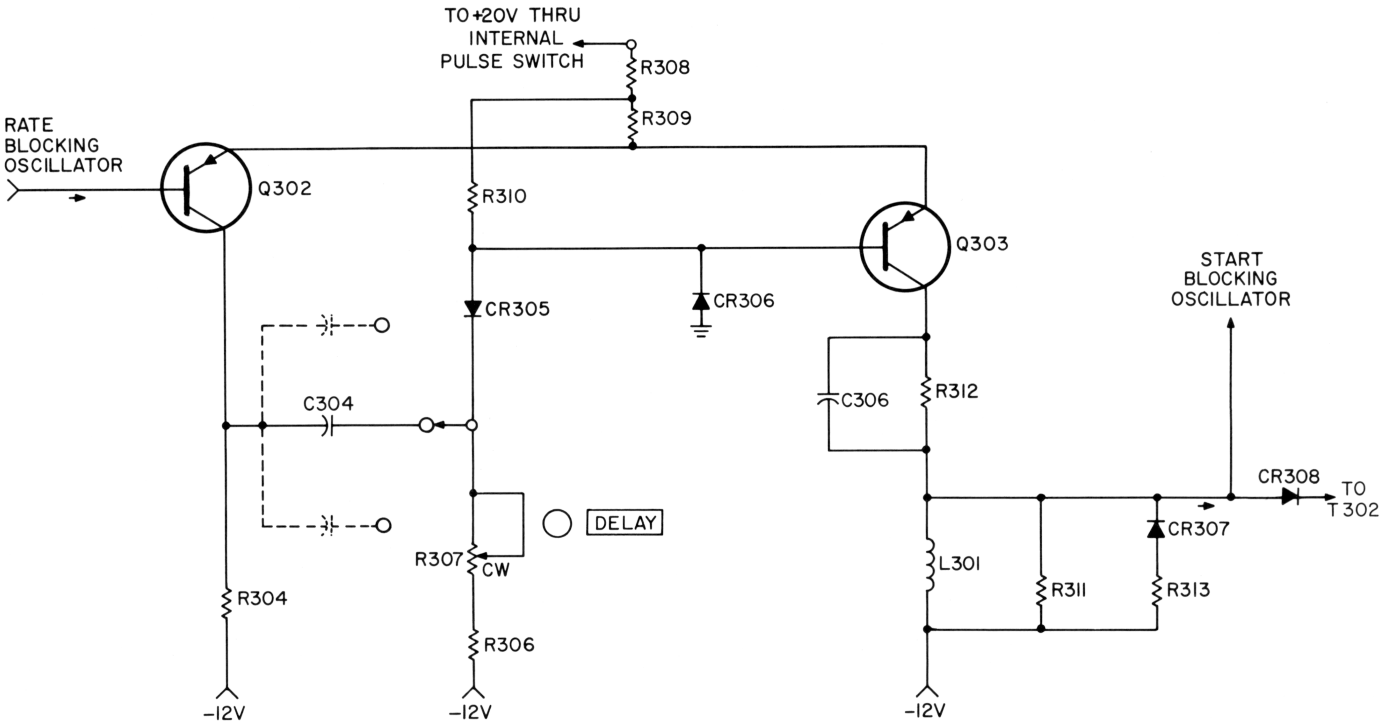



Figure 4-11. Delay Multivibrator

4-30. DELAY AND WIDTH MULTIVIBRATOR.

4-31. The delay and width multivibrator are identical. The delay multivibrator (see Figure 4-11) is monostable and includes Q302 and Q303. Before a trigger pulse is applied to the circuit, Q303 is conducting. The base of Q303 is at about -0.7 volt due to conduction of CR305 and CR306, and capacitor C304 is charged. When the trigger is applied, Q302 conducts and C304 discharges through DELAY (SEC) vernier R307. Discharge of C304 back-biases CR305, causing the base of Q303 to go positive with respect to the emitter. This cuts Q303 off and it remains off until C304 discharges enough to allow CR305 to conduct and forward-bias Q303. Another cycle will not start until triggered again by the rate blocking oscillator.

4-32. An integrating-differentiating circuit is placed in the collector circuit of Q303. Its purpose is to maintain a constant impedance at the collector yet obtain a differentiated output from the circuit.

4-33. BISTABLE MULTIVIBRATOR CIRCUIT.

4-34. Shown in Figure 4-12, the bistable multivibrator provides the pulse required to turn the pin bias circuit on or off and switch the general pulse output circuit from one state to the other. Each half of the circuit when conducting holds the other half off.

4-35. The RC networks (C103, R115, and C104, R116) provide trigger pulses when either the AM or pulse switches are depressed to set bistable multivibrator operation. In the AM mode of operation, the bistable multivibrator is set to produce a minimum attenuation condition at one PIN modulator. In the external pulse mode of operation the bistable multivibrator is set to produce a maximum attenuation condition at PIN Modulator and -11 volt DC signal at general pulse output.

4-36. PIN BIAS CURRENT SUPPLY.

4-37. A simplified drawing of the PIN bias supply is shown in Figure 4-13. The PIN bias supply provides the proper current to the PIN modulator to produce attenuation of 80 dB or more. Q407 is an electronic switch which is controlled by the bistable multivibrator. When Q407 is conducting, current determined by the setting of PIN diode bias adjust R417 is applied to the PIN modulator. When Q407 is biased off, approximately +7.4 volts is applied to the PIN modulator. Thus the circuit looks like a current source when Q407 is conducting, and it looks like a voltage source when Q407 is not conducting.

## 4-38. DUTY LIMIT INDICATOR CIRCUIT .

4-39. The duty limit circuit is shown in Figure 4-14. The maximum duty cycle of the instrument is dependent on pulse-rate, delay and width control settings. To insure that control settings do not result in a pulse which exceeds the duty cycle limit, a duty-limit circuit is provided for the internal pulse mode only. If duty limit is exceeded, the Duty Limit Lamp (D32) will light.

4-40. The circuit is powered by the -12V supply, through R2, INTERNAL pulse switch S3 and rate, delay and width multiplexer switches. When rate multiplier is in the X1000 position and delay and/or width multipliers are in the X10 position, the lamp will light.

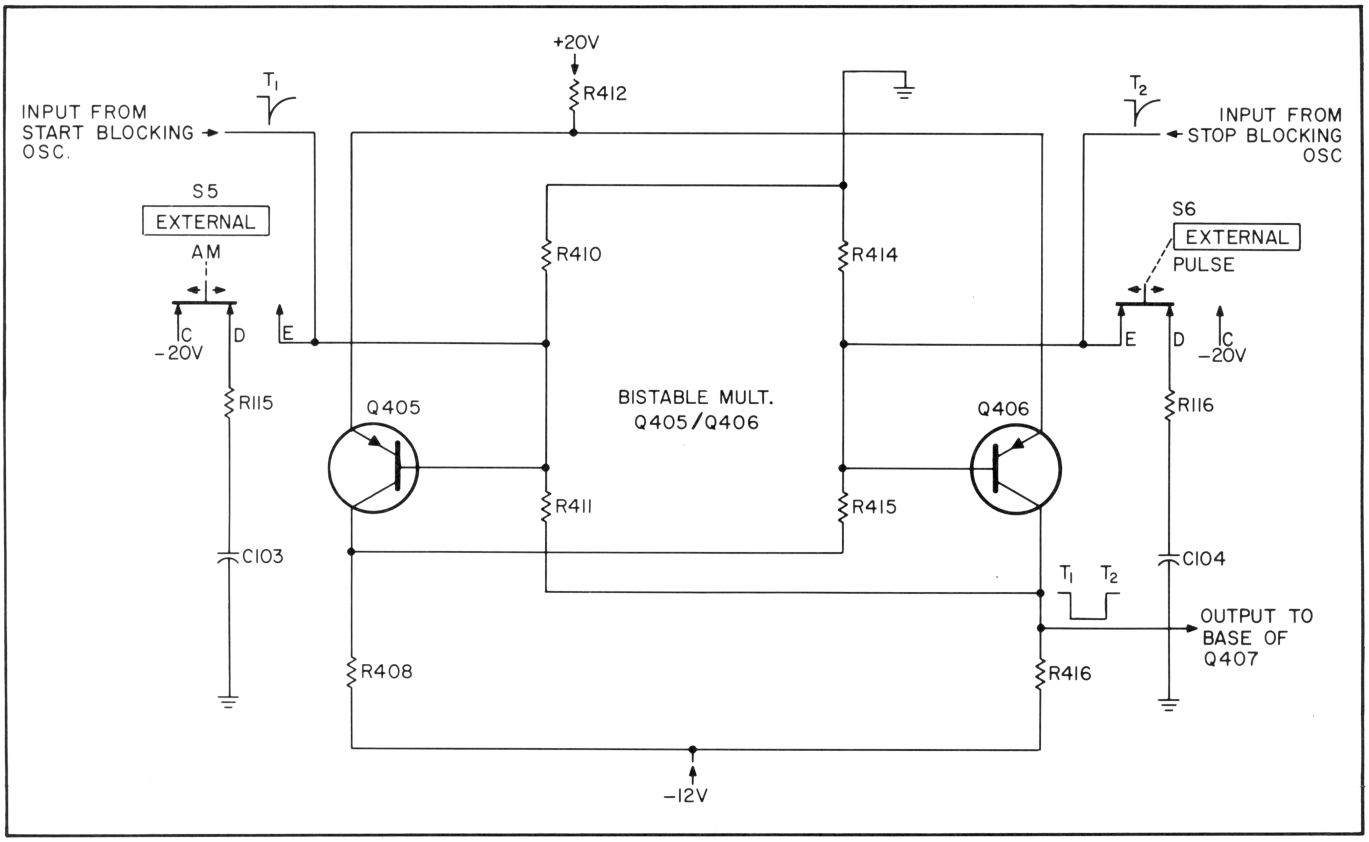



Figure 4-12. Bistable Multivibrator

## 4-41. REGULATED POWER SUPPLY.

4-42. The regulated power includes three power supplies: the +20 volt supply, the -20 volt supply, and the -12 volt supply. All three supplies are conventional series-regulated types. The series regulator is connected in series with the main load. The output voltage is monitored and compared to a reference voltage. The voltage differential between the monitored and reference voltage is applied through a control amplifier to the series regulator. This differential voltage changes the effective resistance of the series regulator which in turn holds the output voltage constant (see Figure 4-15).

4-43. Basically all three of the power supplies operate in the manner described above although differences do exist in the +20 and -20 volt supplies. The +20 volt supply uses a differential amplifier as the control amplifier. This arrangement produces greater gain and ripple rejection, thus a more stable power supply. The -20 volt supply, referenced to the low impedance +20 volt supply, does not need a differential amplifier. The -20 volt supply uses a reference amplifier, Q501, to provide a constant DC collector voltage to Q508 and Q510.

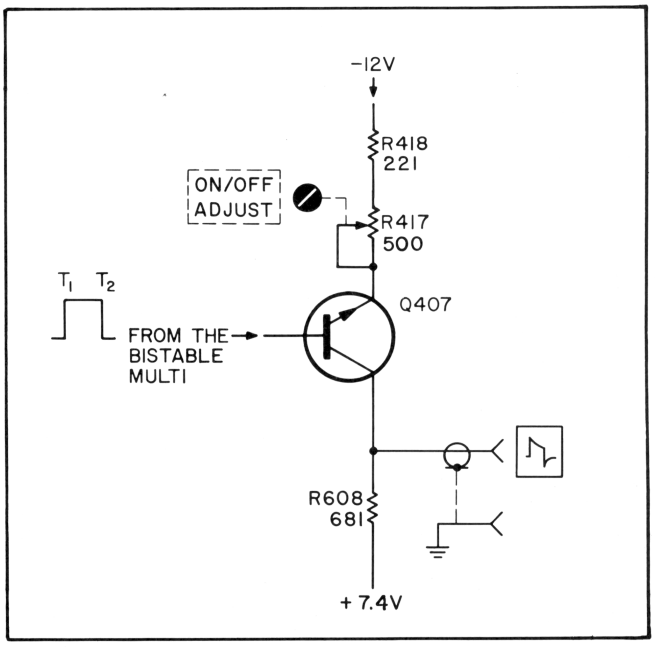



Figure 4-13. PIN Bias Circuit

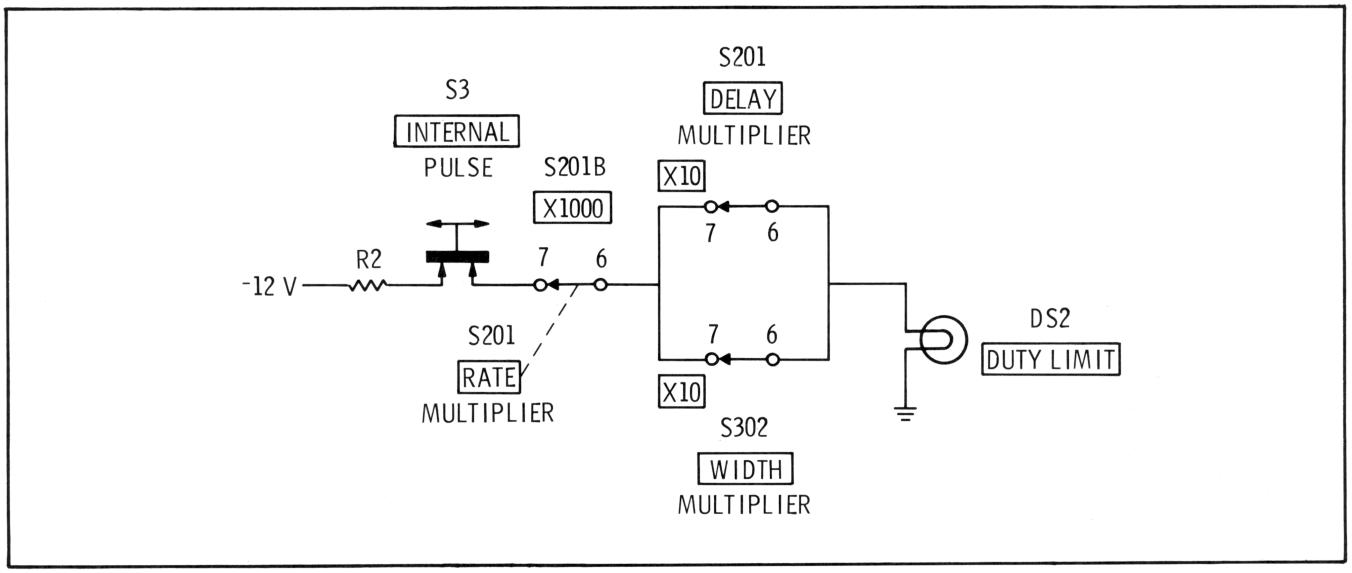



Figure 4-14. Duty Limit Circuit

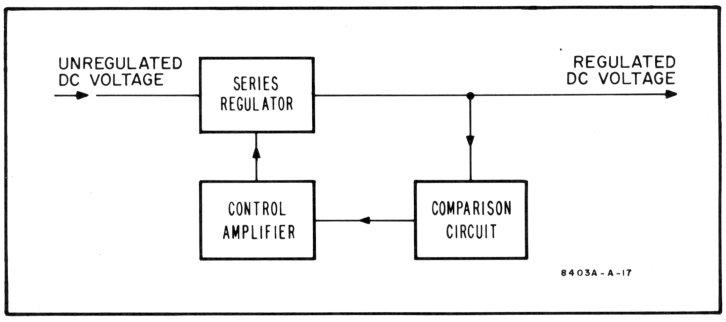



Figure 4-15. Regulated Power Supply

Table 5-1. Test Equipment Recommended

| Instrument Type | Test Use | Critical Specifications | Recommended hp Model |
|---|---|---|---|
| Oscilloscope | Performance, Calibration, Troubleshooting | Range: 0.1-5$\mu$sec/cm<br>Sweep Accuracy: ±5%<br>Attenuator Accuracy: ±3%<br>Dual Channel<br>Sensitivity: 0.05V/cm<br>Rise Time: 7 nsec<br>Bandwidth: 40 MHz | HP 140A (Oscilloscope) with HP 1402A (Dual Trace Amplifier with 10003A/B (X10 Voltage Divider Probe) |
| Test Oscillator | Performance | Range: 10 Hz to 10 MHz<br>Output: 0.5 to 3.0V RMS, sinusoidal, into 600 ohms. | HP 651B |
| DC Voltmeter (see footnote) | Calibration, Troubleshooting | Range: 1 to 45V DC<br>Accuracy: ±0.3% | HP 3440A (DC-VM) with HP 3441A (Plug-in) |
| General Purpose Multimeter (see footnote) | Calibration, Troubleshooting | Range: 1 to 45V DC<br>Range: 0.5 to 150 mA<br>Accuracy: ±3% | HP 410C (Multimeter) or HP 412A (DC Multimeter) |
| BNC Tee connectors | Performance | Three connector BNC junction: one male and two female connectors | UG-274A/U (hp Part No. 1250-0072) |
| BNC to Banana Post Adapter | Performance | Male BNC connector to dual binding post junction | HP 10110A |
| AC Voltmeter | Calibration | Range: 0.001 to 0.010 VAC<br>Accuracy: ±2% | HP 400D |
| Variable Power Transformer | Troubleshooting, Calibration | Range: 103 to 254 VAC at 7-1/2 A<br>Voltmeter Range: 103 - 254 VAC<br>Voltmeter Accuracy: ±1V | General Radio W10MT3A or Superior Electric UC1M |

NOTE: The Model 3440A with the 3444A DC Multi-function plug-in unit may be used as both the DC voltmeter and the general purpose multimeter

# SECTION V
# MAINTENANCE

## 5-1. INTRODUCTION.

5-2. This section provides instructions for performance testing, calibrating, troubleshooting, and repairing the Modulator.

## 5-3. PERFORMANCE TESTS.

5-4. PURPOSE. The procedures listed in Table 5-3 check Modulator performance for incoming inspection, periodic evaluation, calibration, and troubleshooting. The tests can be performed without access to the Modulator interior. The specifications of Table 1-1 are the performance standards. For PIN Modulators, which may be included as Options 01 through 09, refer to Table 2 of the PIN Modulator Operating Note which is included in the Appendix section at the rear of this manual.

5-5. TEST EQUIPMENT REQUIRED. The test instruments required to make the performance checks are listed in Table 5-1. Test instruments other than the ones listed may be used provided their performance equals or exceeds the Critical Specifications.

Note

It is not necessary to remove pin modulators from 8403A unit in order to conduct Performance Tests.

## 5-6. CALIBRATION.

5-7. POWER SUPPLY.

a. Remove instrument top and bottom covers.

b. Remove power supply plug-in A500 and replace with a plug-in extender (supplied with instrument) to make power supply adjustments accessible.

**CAUTION**

NEVER REMOVE OR INSTALL POWER SUPPLY PLUG-IN WITH POWER ON. THE TRANSISTORS IN ALL THREE POWER SUPPLIES CAN BE DAMAGED.

c. Connect AC power line to a variable AC power source. Set AC voltage at 115 VAC (or 230 VAC as appropriate).

d. Set 8403A as follows:

LINE . . . . . depressed
INTERNAL PULSE . . . . . depressed

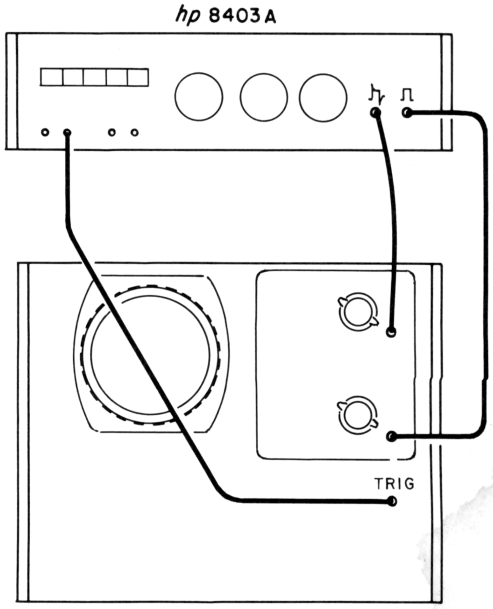



Figure 5-1. Dial Calibration

RATE multiplier . . . . . X1000
RATE vernier. . . . . 0.5
DELAY multiplier . . . . . X1.0
WIDTH multiplier . . . . . X1.0

e. Using a DC digital voltmeter and an AC VTVM in parallel make the measurements indicated in Table 5-2.

5-8. RATE DIAL.

a. Connect 8403A as shown in Figure 5-1.

b. Set 8403A as follows:

LINE . . . . . depressed
INTERNAL PULSE . . . . . depressed
RATE multiplier . . . . . X100
DELAY multiplier . . . . . X1.0
WIDTH multiplier . . . . . X1.0

c. Adjust RATE vernier for a 1-KHz indication on oscilloscope.

d. Loosen allen setscrews on RATE vernier, slip dial to read 10, and tighten one allen setscrew.

e. Check RATE from 50 to 50,000 Hz and reslip dial if necessary to minimize error. Tighten both allen setscrews.

Table 5-2. Power Supply Adjustment

| Supply | Measure Point | Adjust | Measure | Ripple | Line Voltage |
|---|---|---|---|---|---|
| +20V | +20V bus to ground | R507* | +20 ±0.2V | 0.005 V (RMS) | 103 to 127 VAC or 207 to 253 VAC |
| -20V | -20V bus to ground | R519* | -20 ±0.2V | 0.010 V (RMS) | |
| -12V | -12V bus to ground | R507* | -12 ±0.1V | 0.005 V (RMS) | |

* Set the +20 volt supply adjustment R507 first. Set the -20 volt supply adjustment R519 second. The -12 volt supply adjustment R507 should not need adjustment as it is referenced to the +20 volt supply. If R507 is adjusted for the -12 volt supply, all supplies should be checked again.

5-9. DELAY DIAL.

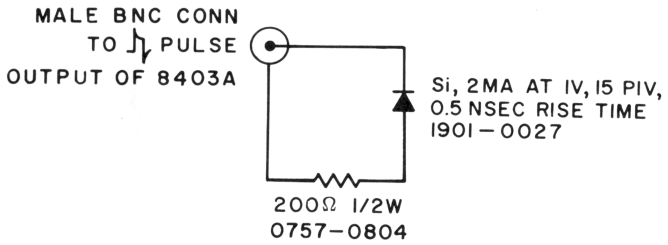
a. Connect 8403A as shown in Figure 5-1.
b. Set 8403A as follows:

| | |
|---|---|
| LINE | depressed |
| INTERNAL PULSE | depressed |
| RATE multiplier | X1000 |
| RATE vernier | 5 |
| DELAY multiplier | X1.0 |
| WIDTH multiplier | X1.0 |

c. Adjust DELAY vernier for a 5-$\mu$sec delay presentation on oscilloscope.
d. Loosen DELAY vernier allen setscrews and slip dial to indicate 5. Tighten one allen setscrew.
e. Check dial accuracy for 0.1 to 100 $\mu$sec and reslip dial for best overall accuracy. Tighten both setscrews.

5-10. WIDTH DIAL.

a. Connect 8403A as shown in Figure 5-1 using 10003A/B (X10 Voltage Divider Probe) in place of coaxial leads going to ⊓ and ⊓ pulse outputs from oscilloscope.
b. Connect dummy load to ⊓ PULSE OUTPUT at J105. Leave ⊓ PULSE OUTPUT unloaded.




⊓ Output Dummy Load

c. Connect one probe to center conductor of ⊓ OUTPUT J105 and the other probe to the ⊓ OUTPUT.
d. Set 8403A as follows:

| | |
|---|---|
| LINE | depressed |
| INTERNAL | depressed |
| RATE multiplier | 1000 |
| RATE vernier | 5 |
| DELAY multiplier | X1 |
| DELAY vernier | 5 |
| WIDTH multiplier | X1.0 |

e. Adjust WIDTH vernier for a 5-$\mu$sec presentation on Oscilloscope.
f. Loosen two allen setscrews holding WIDTH vernier dial and slip dial to indicate 5. Tighten one allen setscrew.
g. Check dial accuracy from 0.1 to 100 $\mu$sec at a rate of 5000 Hz. Reslip dial for best accuracy obtainable. Tighten both allen setscrews.

5-11. DUTY LIMIT LAMP.

a. To check operation of duty limit lamp, connect 8403A power cord to a Variable Power Transformer.
b. Set Variable Power Transformer to high-line voltage (i.e., 127 VAC - 115 VAC operation or 253 VAC - 230 VAC operation).
c. Set 8403A as follows:

| | |
|---|---|
| LINE | depressed |
| INTERNAL PULSE | depressed |
| RATE multiplier | X1000 |
| RATE vernier | 1 |
| DELAY multiplier | X10 |

d. The DUTY LIMIT lamp should flash, but not remain lit. If DUTY LIMIT lamp remains lit then R602 should be removed from A600 assembly circuit board and replaced with a resistor whose value is between 900K ohm and 1 Megohm.

Table 5-3. Performance Test Procedure

1. **OUTPUT CHARACTERISTICS.** One pulse output specially shaped for optimum RF rise and decay times; one pulse output for general pulse applications: positive DC-coupled 25 to 30 volts in amplitude, approximately symmetrical about 0 volt DC.

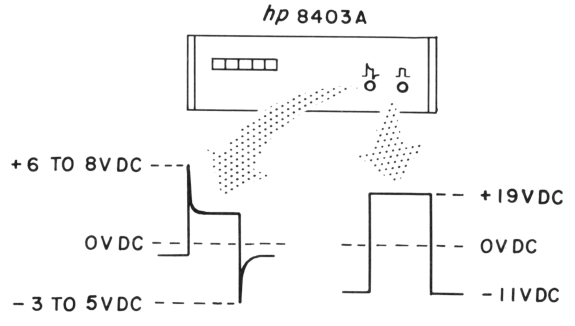
PROCEDURE

a. Using an Oscilloscope, with 50 MHz Vertical Amplifier and X10 Attenuator Divider Probe, measure PULSE OUTPUTS as follows:

(1) Depress LINE and INT PULSE buttons and set RATE CPS to X100.

(2) Connect a Dual Banana post to BNC adapter to appropriate PULSE OUTPUT connector and connect Oscilloscope Probe to adapter.

(3) Observed waveforms should be about as shown in Figure to the right.




NOTES

Table 5-3. Performance Test Procedure (cont'd)

**2. INTERNAL SQUARE WAVE MODULATION:** Frequency variable from 50 Hz to 50 KHz; better than 45/55%.

PROCEDURE

a. Connect 8403A as shown on next page.

b. Depress LINE and SQ WAVE buttons.

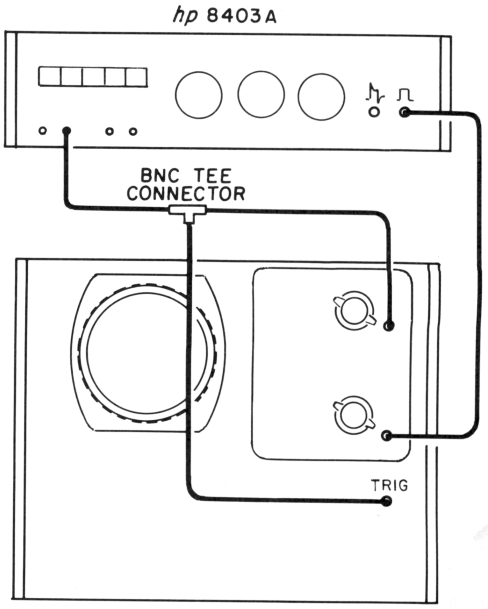
c. Set RATE CPS to 50 X1000.

d. Set Oscilloscope sweep time to 2 μsec/cm.

e. Readjust RATE CPS control to display one complete square wave cycle on Oscilloscope, Square wave symmetry should be better than 45/55%.

f. Set RATE CPS to 5 X10 and Oscilloscope sweep time to 0.2 msec/cm.

g. Readjust RATE control, if necessary, for one complete cycle display.




NOTES

**3. INTERNAL PULSE MODULATION.** Repetition rate variable from 50 Hz to 50 KMz.

PROCEDURE

a. Connect 8403A as shown for square wave check.

b. Set 8403A as follows:

| | |
|---|---|
| LINE | depressed |
| internal PULSE | depressed |
| WIDTH | X1.0 |
| DELAY | X1.0 |
| RATE (vernier) | full clockwise |
| RATE | X10 |

c. Set Oscilloscope sweep time to 5 ms/cm.

d. Observed pulses should be at least 20 ms apart.

e. Set RATE vernier fully counterclockwise and RATE to X1000.

f. Set Oscilloscope sweep time to 20 μsec/cm.

g. Observed pulses should not be greater than 20 μsec apart.

NOTES

Table 5-3. Performance Test Procedure (cont'd)

**4. INTERNAL PULSE MODULATION.** Delay variable from 0.1 to 100 μseconds between sync output pulse and pulse output

| PROCEDURE | NOTES |
|---|---|
| a. Connect 8403A as shown under INTERNAL SQUARE WAVE MODULATION.<br>b. Set 8403A as follows:<br>LINE ..... depressed<br>INTERNAL PULSE ..... depressed<br>RATE ..... X100<br>DELAY ..... 0.1<br>DELAY (vernier) ..... full clockwise<br>c. Set Oscilloscope sweep time to 0.1 μsec/cm.<br>d. The measured pulse delay should be not greater than 0.1 μsec plus Oscilloscope delay time.<br>e. Set DELAY (vernier) full counterclockwise and DELAY to X10.<br>f. Set Oscilloscope sweep time to 20 μsec/cm.<br>g. The measured pulse delay should be greater than 100 μsec minus Oscilloscope delay time. | |

**5. INTERNAL PULSE MODULATION:** Width variable from 0.1 to 100 μsec.

| PROCEDURE | NOTES |
|---|---|
| a. Connect 8403A as shown for internal square wave check.<br>b. Set 8403A as follows:<br>LINE ..... depressed<br>INTERNAL PULSE ..... depressed<br>RATE ..... X100<br>DELAY ..... X.1<br>WIDTH (vernier) ..... full clockwise<br>WIDTH ..... X.1<br>c. Set Oscilloscope sweep time to 0.02 μsec.<br>d. Pulse width should be less than 0.1 μsec.<br>e. Rotate WIDTH vernier fully counterclockwise and WIDTH to X10.<br>f. Set Oscilloscope sweep time to 20 μsec/cm.<br>g. Pulse width should be greater than 100 μsec. | |

**6. EXTERNAL SYNC.** Amplitude and Polarity: 5 to 15V peak, either positive or negative.

Waveform: Pulse or sine wave.(see Note 1)
Rate (see Note 1): Maximum average prf, 1 MHz
Maximum peak prf, 2 MHz

| PROCEDURE | NOTES |
|---|---|
| a. Connect 8403A as shown for square wave check.<br>b. Set 8403A as follows:<br>LINE ..... depressed<br>INTERNAL PULSE ..... depressed<br>RATE CPS ..... EXT SYNC<br>c. Set polarity switch (located beneath EXTERNAL PULSE button) to +. | |

Table 5-3. Performance Test Procedure (cont'd)

| | |
|---|---|
| d. Apply synchronizing 5 to 15V peak sine wave signal to input connector located beneath EXTERNAL PULSE button.<br>e. Pulse presentation on Oscilloscope should be variable in delay and width. No jitter should be present if 8403A dutycycle limit is not exceeded.<br>f. Set polarity switch to -. Pulse presentation should not change. | |

**7. TRIGGER OUT. FOR INTERNAL PULSE OPERATION ONLY:**
Sync Out: 0.1 to 100 $\mu$sec in advance of PULSE OUTPUTS, as set by DELAY control (-2V amplitude).
DELAYED sync out: Coincident with PULSE OUTPUTS (-2V amplitude).

| PROCEDURE | NOTES |
|---|---|
| a. For checking Sync Out, refer to instruction number 4 in this table.<br>b. For checking DELAYED sync output, move 8403A cable connection from sync output connector to the DELAYED sync output connector.<br>c. The Oscilloscope pulse presentations should be coincident. | |

**8. EXTERNAL PULSE MODULATION.** Repetition rate variable up to 1 MHz average prf, 2 MHz peak prf (see Note 1)

| PROCEDURE | NOTES |
|---|---|
| a. Check 8403A operation using procedure outlined for EXTERNAL SYNC check except that EXTERNAL PULSE button should be depressed instead of INTERNAL PULSE button. | |

**9. CONTINUOUS AMPLITUDE MODULATION:**
Max Frequency response: 10 MHz, sinusoidal
Input impedance: 1000 ohms
Level Control: rear panel AM OPER POINT control sets average DC input level.

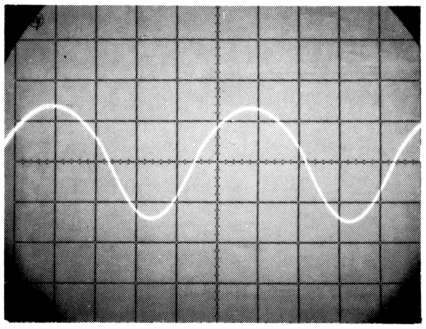
| PROCEDURE | |
|---|---|
| a. Connect special shaped PULSE OUTPUT connector to Oscilloscope and set Oscilloscope for internal sync.<br>b. Set 8403A as follows:<br>LINE ..... depressed<br>RATE ..... EXT SYNC<br>AM ..... depressed |  <br>PULSE OUTPUT: AM OPERATION (IKHz, Iv RMS INPUT SIGNAL; SWEEP TIME .2ms/cm ) |

Table 5-3. Performance Test Procedure (cont'd)

| | |
|---|---|
| c. Apply a 1 KHz, sine wave signal, approximately 1 volt RMS amplitude) to the AM input (directly be-beneath AM button).<br><br>d. Set Oscilloscope sweep time to 0.2 ms/cm and vertical input for 0.5 V/cm (AC coupled).<br><br>e. Adjust rear panel AM OPER POINT control for a distorted signal similar to that pictured on previous page.<br><br>f. Adjust AM OPER POINT control to eliminate distortion. Note: If input signal amplitude is too large, the distortion can not be eliminated.<br><br>g. Change Oscilloscope sweep time to 2 $\mu$sec/cm and AM signal input frequency to 10 MHz. Adjust input signal amplitude to obtain about a 1.5 volt peak-to-peak Oscilloscope display. Repeat steps e and f.<br><br>h. Repeat above procedure optionally at all other frequencies of interest. | NOTES |

**NOTE**

1. The maximum externally-applied pulses-per-second rating of the 8403A is 1,000,000 pps. Application of more than 1,000,000 pulses within a one-second interval can destroy internal components. However, the 8403A can be triggered for short durations at an externally-applied 2,000,000 pps rate provided the number of applied pulses does not exceed 1,000,000 pulses within one second. For example: pulse spacing as low as 0.5 $\mu$sec (2,000,000 pps rate) may be used provided there are not more than one million pulses during one second.

## 5-12. TROUBLESHOOTING.

5-13. The troubleshooting procedure given for the 8403A isolates trouble to a stage. The procedure should be performed in three (four for 8403A-Option 01 through 08 instruments) sequential steps.

Note

For a complete discussion of transistor troubleshooting techniques, refer to Paragraph 5-14.

a. Step 1: Power Supplies. The +20 and -20 volt supplies are interrelated. The -12 volt supply is referenced to the +20 volt supply. Thus trouble in the +20 volt supply will affect all supplies. Trouble in the -12 volt supply will not affect the other supplies. A power supply malfunction will usually affect all modes of operation (see Table 5-4).

CAUTION

NEVER REMOVE OR INSTALL POWER SUPPLY PLUG-IN A500 WITH AC POWER ON. THE TRANSISTORS IN THE 8403A CAN BE DAMAGED.

b. Step 2: Troubleshooting Chart. Check instrument trouble symptoms against those listed in Table 5-5, Troubleshooting.

Table 5-4. Troubleshooting Power Supplies

| Supply | Test Point | Measure | Possible Cause |
|---|---|---|---|
| +20 V | +20 V bus | +20 ±0.2 Vdc<br>+20 ±2.0 Vdc<br>+20 ±20 Vdc | Supply OK<br>Q509 shorted, CR509<br>Q501 shorted, CR504 or open |
| -20 V | -20 V bus | -20 ±0.2 Vdc<br>-20 ±3.0 Vdc<br>-20 ±20 Vdc | Supply OK<br>Q501 shorted<br>Q509 shorted or open |
| -12 V | -12 V bus | -12 ±0.1 Vdc<br>-12 ±1.0 Vdc<br>-12 ±12 Vdc | Supply OK<br>Q501 shorted<br>Q505 shorted or open |

c. Step 3: Isolating Trouble to a Specific Circuit. Because each mode of operation uses different circuit combinations, trouble can be isolated to a specific circuit by checking the operation of each in a prescribed sequence. In addition, waveforms are given with critical voltage at key circuit points on each schematic diagram.

Note: For Option instruments including an internally mounted PIN Modulator, remove instrument bottom cover and disconnect J105-to-BIAS connector cable. Use J105 as Specially Shaped output for testing purposes.

(1) Use procedure given in Table 5-3 to check operation of the external pulse circuit. If the circuit is not functioning properly, the trouble could be in the Schmitt trigger circuit, positive or negative spiker, or bistable multivibrator circuits. Use an oscilloscope to check waveforms shown at key circuit points to isolate the trouble.

(2) Use procedure given in Table 5-3 to check square wave circuit. If the circuit is not functioning properly, the trouble is located in the rate circuit. If circuit is functioning properly, proceed to step (3).

(3) Check delay and width circuits (see Table 5-3). If circuits are functioning properly, proceed to step (4).

(4) Use procedure given in Table 5-3 to check external AM circuit. If circuit is not functioning properly, check R606, S5, and CR603.

d. Step 4: For Option 01 through 08 Instruments ONLY. Once instrument circuit operation has been found satisfactory, refer to MAINTENANCE section of PIN Modulator Operating Note which is included in Appendix II at rear of this manual for performance check procedure.

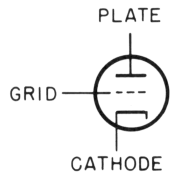
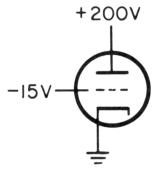
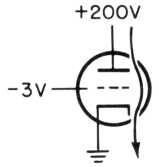
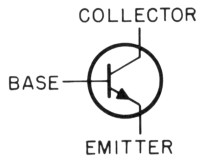
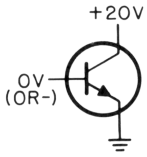
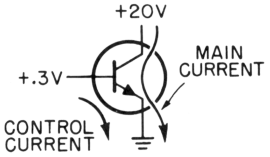
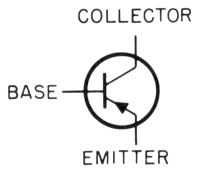
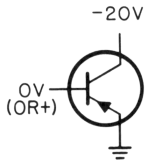
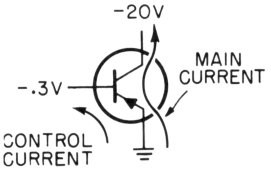
## 5-14. TRANSISTOR TROUBLESHOOTING.

5-15. The following procedures and data are given to aid in determining whether a transistor is operational. Tests are given for both in-circuit and out-of-circuit transistors.

Table 5-5. Troubleshooting

| Symptom | Trouble Location | Check |
|---|---|---|
| External functioning in positive and negative | Input Amplifier/Inverter | CR101, CR102, CR103, CR104 |
| Spiker output becomes distorted with sine and square wave inputs @ 500 kHz | Positive Spiker | Q402 |
| | Negative Spiker | Q404 |
| No external pulse<br>No external sync | Schmitt trigger circuit | Q101, Q102, Q103, Q104 |
| No negative external trigger or sync | Trigger circuit | CR103, CR104, S101 |
| No positive external trigger or sync | Trigger circuit | CR101, CR102, S101 |
| Weak sync signal | Sync output blocking oscillator | CR203 through CR206 |
| No square wave<br>No internal pulse | Rate multivibrator | Q201, Q202, Q203, Q204 |
| No sync out pulse in external pulse, internal pulse or external sync | Sync out blocking oscillator | Q205, CR203, CR204 |
| Double sync | Delayed sync output blocking oscillator | Q304,<br>Reverse T302 |
| No external sync<br>No internal pulse<br>No delayed sync pulse output | Delay multivibrator, rate blocking oscillator | Q301, Q302, Q303 |
| No external sync<br>No internal pulse, delayed sync pulse OK<br>RF on continuously in external sync and internal pulse | Width multivibrator | Q305, Q306, CR405 |
| No external sync | Rate blocking oscillator | CR302 |
| No internal sync | Rate blocking oscillator | CR301 |
| No signal on collector of Q401 and Q403 | Start Blocking Oscillator | CR401, CR402, CR403 |
| | Stop Blocking Oscillator | CR408, CR409, CR410 |
| Multivibrator doesn't flip | Start Blocking Oscillator | CR406 |
| | Stop Blocking Oscillator | CR413 |
| Spiker output distorted or insufficient DC level | Positive Spiker | Q402, CR407 |
| | Negative Spiker | Q404, CR412 |
| Poor rise time on RF pulses | Positive Spiker | Q402 |
| Poor delay time on RF pulses | Negative Spiker | Q404 |
| RF on or off continuously, sync out OK, delayed sync OK | Bistable circuits<br>Start blocking oscillator | Q405, Q406 |

## A. TRANSISTOR BIASING

| DEVICE | SYMBOL | CUTOFF | CONDUCTING |
|---|---|---|---|
| VACUUM TUBE |  |  |  |
| N P N TRANSISTOR |  |  |  |
| P N P TRANSISTOR |  |  |  |

## B. AMPLIFIER CHARACTERISTICS

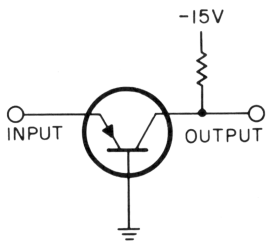
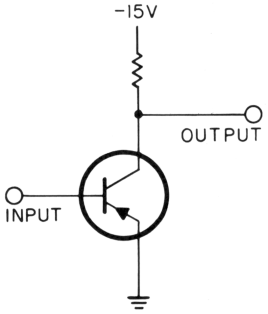
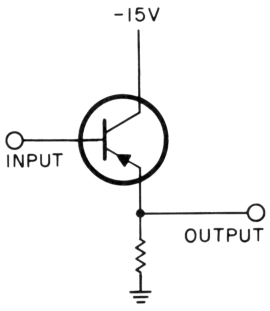
| CHARACTERISTIC | COMMON BASE | COMMON EMITTER | COMMON COLLECTOR |
|---|---|---|---|
| INPUT Z | 30-50 Ω | 500-1500 Ω | 20-500K Ω |
| OUTPUT Z | 300-500K Ω | 30-50K Ω | 50-1000 Ω |
| VOLTAGE GAIN | 500-1500 | 300-1000 | <1 |
| CURRENT GAIN | <1 | 25-50 | 25-50 |
| POWER GAIN | 20-30 dB | 25-40 dB | 10-20 dB |
| |  |  |  |

Figure 5-2. Transistor Operation

5-16. IN-CIRCUIT TESTING.

5-17. The common causes of transistor failures are internal short- and open-circuits. In transistor circuit testing the most important consideration is the transistor base-emitter junction. Like the control grid of a vacuum tube, this is the operational control point in the transistor. This junction is essentially a solid state diode. For the transistor to conduct, the diode must conduct; that is, the diode must be forward biased. As with simple diodes, the forward-bias polarity is determined by the materials forming the junction. Use the transistor symbol on the schematic diagram to determine the bias polarity required to forward-bias the base-emitter junction. The A part of Figure 5-2 shows transistor symbols with terminals labeled. Notice that the emitter arrow conventionally points toward the type N material. The other two columns of the illustration compare the biasing required to cause conduction and cut-off in transistors and vacuum tubes. If the transistor base-emitter diode (junction) is forward-biased the transistor conducts. If the diode is heavily forward-biased the transistor saturates. However, if the base-emitter diode is reverse-biased the transistor is cut off. The voltage drop across a forward-biased emitter-base diode varies with transistor collector current. For example, a germanium transistor has a typical forward-bias, base-emitter voltage of 0.2 - 0.3 volts when collector current is 1 - 10 mA, and 0.4 - 0.5 volts when collector current is 10 - 100 mA. In contrast, forward bias voltage for silicon transistors is about twice that for germanium types: about 0.5 - 0.6 volts when collector current is low, and about 0.8-0.9 volts when collector current is high.

5-18. Figure 5-2, part B, shows simplified versions of the three basic transistor circuits and gives the operating characteristics of each. When examining a transistor stage, first determine if the emitter-base diode is biased for conduction (forward-biased) by measuring the voltage difference between emitter and base. When using an electronic voltmeter, do not measure directly between emitter and base: there may be sufficient loop current between the voltmeter leads to damage the transistor. Instead, measure each voltage separately with respect to a voltage common point (e.g., chassis). If the emitter-base diode is forward-biased, check for amplifier action by short-circuiting base to emitter while observing collector voltage. The short-circuit eliminates base-emitter bias and should cause the transistor to stop conducting (cut off). Collector voltage should then shift to near the supply voltage. Any difference is due to leakage current through the transistor and in general, the smaller this current, the better the transistor. If collector voltage does not change, the transistor has either an emitter-collector short circuit or emitter-base open circuit.

5-19. TESTING TRANSISTORS WITH AN OHMMETER.

5-20. The two common causes of transistor failure are internal short- and open-circuits. Remove the transistor from the circuit and use an ohmmeter to measure internal resistance. See Table 5-6 for measurement data.

Table 5-6. Out-of-Circuit Transistor Resistance Measurement

| Transistor Type | | Connect Ohmmeter Pos. lead to | Connect Ohmmeter Neg. lead to | Measure Resistance (ohms) |
|---|---|---|---|---|
| PNP Germanium | Small Signal | emitter | base* | 200 - 500 |
| | | emitter | collector | 10K - 100K |
| | | emitter | base* | 30 - 50 |
| | Power | emitter | collector | several hundred |
| NPN Silicon | Small Signal | base | emitter | 1K - 3K |
| | | collector | emitter | very high (might read open) |
| | | base | emitter | 200 - 1000 |
| | Power | collector | emitter | high, often greater than 1 M |

*To test for transistor action, add collector-base short. Measured resistance should decrease.

CAUTION

Most ohmmeters can supply enough current or voltage to damage a transistor. Before using an ohmmeter to measure transistor forward or reverse resistance, check open-circuit voltage and short-circuit current output ON THE RANGE TO BE USED. Open circuit voltage must not exceed 1.5 volts and short-circuit current must be less than 3 mA. See Table 5-7 for safe resistance ranges for some common ohmmeters.

5-21. ETCHED CIRCUITS.

5-22. The etched circuit board is a plated-through type consisting of metallic conductors bonded to both sides of insulating material. The metallic conductors are extended through the component mounting holes by a plating process. Soldering can be done from either side of the board with equally good results. Table 5-8 lists recommended tools and materials. Following are recommendations and precautions pertinent to etched circuit repair work:

a. Avoid unnecessary component substitution; it can result in damage to the circuit board and/or adjacent components.

b. Do not use a high-power soldering iron on etched circuit boards. Excessive heat may lift a conductor or damage the board.

c. Use a suction device (Table 5-8) or wooden toothpick to remove solder from component mounting holes. DO NOT USE A SHARP METAL OBJECT SUCH AS AN AWL OR TWIST DRILL FOR THIS PURPOSE. SHARP OBJECTS MAY DAMAGE THE PLATED-THROUGH CONDUCTOR.

d. After soldering, remove excess flux from the soldered area and apply a protective coating to prevent contamination and corrosion. See Table 5-8.

Table 5-7. Safe Ohmmeter Range for Transistor Resistance Measurements

| Ohmmeter | Safe Range(s) | Open Ckt Voltage | Short Ckt Current | Lead Color | Lead Polarity |
|---|---|---|---|---|---|
| 412A | R x 1K<br>R x 10K<br>R x 100K<br>R x 1M<br>R x 10M | 1.0V<br>1.0V<br>1.0V<br>1.0V<br>1.0V | 1 mA<br>100 μA<br>10 μA<br>1 μA<br>0.1 μA | Red<br>Blk | +<br>- |
| 410C | R x 1K<br>R x 10K<br>R x 100K<br>R x 1M<br>R x 10M | 1.3V<br>1.3V<br>1.3V<br>1.3V<br>1.3V | 0.57mA<br>57 μA<br>5.7 μA<br>0.5 μA<br>0.05μA | Red<br>Blk | +<br>- |
| 410B | R x 100<br>R x 1K<br>R x 10K<br>R x 100K<br>R x 1M | 1.1V<br>1.1V<br>1.1V<br>1.1V<br>1.1V | 1.1 mA<br>110 μA<br>11 μA<br>1.1 μA<br>0.11 μA | Blk<br>Red | +<br>- |
| Simpson 260 | R x 100 | 1.5V | 1 mA | Red<br>Blk | +<br>- |
| Simpson 269 | R x 1K | 1.5V | 0.82 mA | Blk<br>Red | +<br>- |
| Triplett 630 | R x 100<br>R x 1K | 1.5V<br>1.5V | 3.25mA<br>325 μA | Varies with Serial Number | |
| Triplett 310 | R x 10<br>R x 100 | 1.5V<br>1.5V | 750 μA<br>75 μA | | |

5-23. COMPONENT REPLACEMENT.

a. Remove defective component from circuit board.

b. Remove solder from mounting holes using a suction desoldering aid (Table 5-8) or wooden toothpick.

c. Shape leads of replacement component to match mounting hole spacing.

d. Insert component leads into mounting holes, and position component as original was positioned. DO NOT FORCE LEADS OF REPLACEMENT COMPONENT INTO MOUNTING HOLES. Sharp lead ends may damage plated-through conductor.

Note

Axial lead components, such as resistors and tubular capacitors, can be replaced without unsoldering. Clip leads near body of defective component, remove component and straighten leads left in board. Wrap leads of replacement component one turn around original leads. Solder wrapped connection, and clip off excess lead.

5-24. ETCHED CONDUCTOR REPAIR. A broken or burned section of conductor can be repaired by bridging the damaged section with a length of tinned copper wire. Allow adequate overlap and remove any varnish from etched conductor before soldering wire into place.

5-25. TRANSISTOR REPLACEMENT.

a. Do not apply excessive heat. See Table 5-8 for soldering tool specifications.

b. Use a heat sink such as pliers or hemostat between transistor body and hot soldering iron.

c. When installing a replacement transistor, ensure sufficient lead length to dissipate heat of soldering by maintaining about the same length of exposed lead as used for original translator.

Table 5-8. Etched Circuit Soldering Equipment

| Item | Use | Specification | Item Recommended |
|---|---|---|---|
| Soldering Tool | Soldering<br>Unsoldering | Wattage rating: 37.5<br>Tip Temp: 750 - 800°F<br>Tip Size: 1/8" OD | Ungar #776 Handle with Ungar #1237 Heating Unit |
| Soldering Tip, general purpose | Soldering<br>Unsoldering | Shape: chisel<br>Size: 1/8" | Ungar #PL113 |
| De-soldering aid | Unsoldering multi-connection components (e.g., tube sockets | Suction device to remove molten solder from connection | Soldapullt by the Edsyn Company, Arleta, California |
| Resin (flux) solvent | Remove excess flux from soldered area before application of protective coating | Must not dissolve etched circuit base board matererial or conductor bonding agent | Freon<br>Acetone<br>Lacquer Thinner<br>Isopropyl Alcohol (100% dry) |
| Solder | Component replacement<br>Circuit board repair<br>Wiring | Resin (flux) core, high tin content (60/40 tin/lead), 18 gauge (SWG) preferred | |
| Protective Coating | Contamination, corrosion protection after soldering | Good electrical insulation, corrosion-prevention properties | Krylon* #1302<br>Humiseal Protective Coating, Type 1B12 by Columbia Technical Corp. Woodside 77, New York |

*Krylon Inc., Norristown, Pennsylvania

1. Resistance in ohms, capacitance in microfarads unless otherwise indicated

2. screwdriver adjust

   panel control

3. front panel designation

   rear panel designation

4. etched circuit borderline

   signal path feedback path

5. CW wiper moves toward CW with clockwise rotation of control

6. = test point. Number in circle matches TP number on circuit board illustration.

7. Voltage regulator (breakdown) diode

Figure 5-3. Schematic Diagram Notes

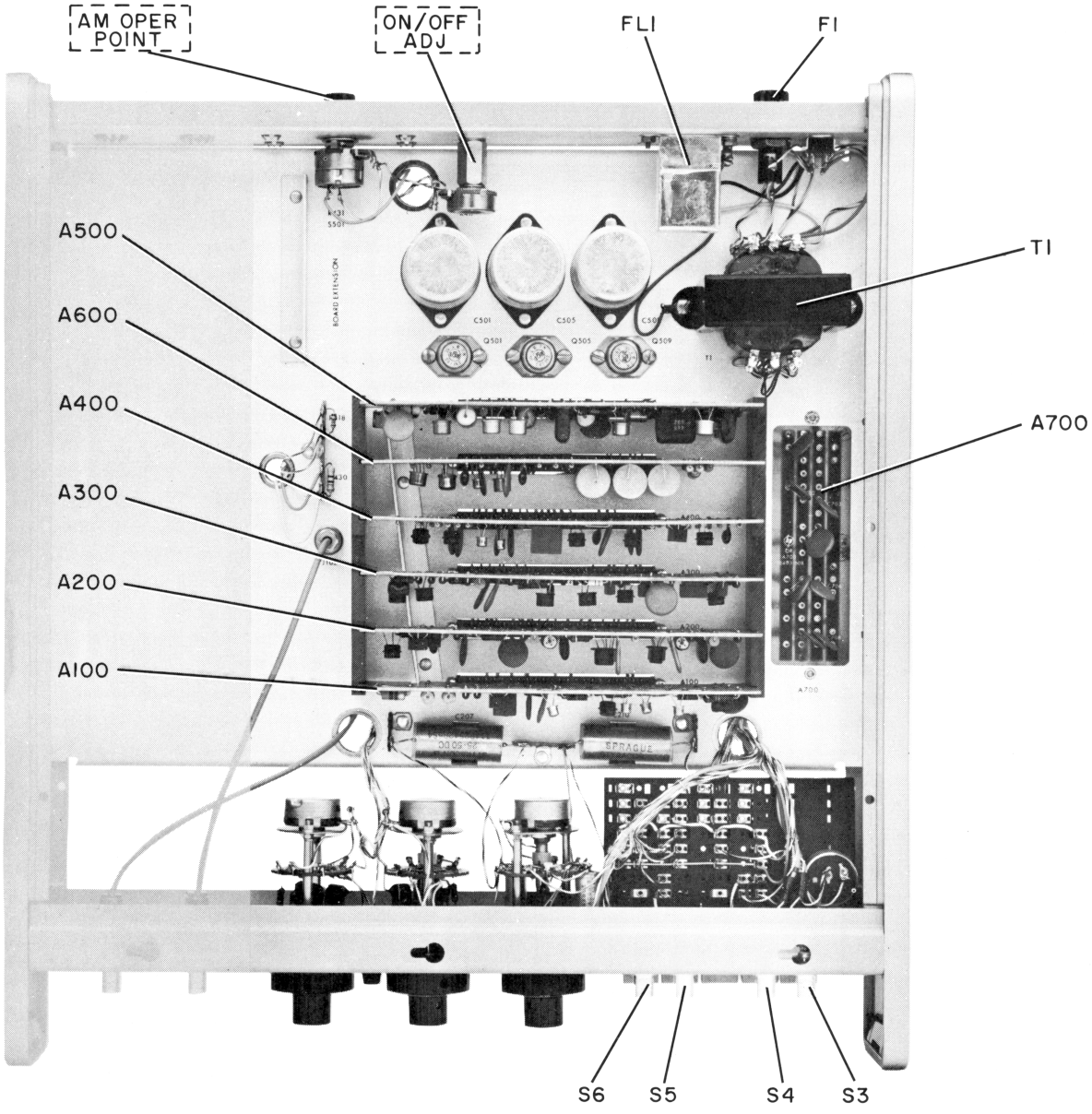



Figure 5-4. Model 8403A, Bottom View

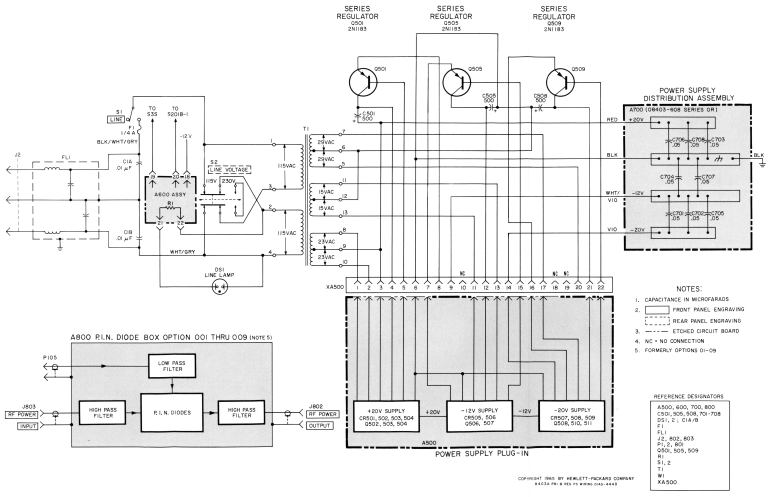



Figure 5-5. Power Supply Wiring Diagram

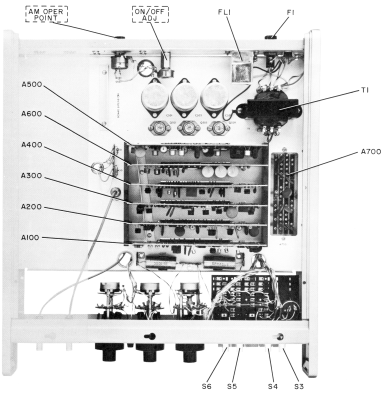



Figure 5-6. Model 8403A, Bottom View

REFERENCE DESIGNATORS

A500, 600, 700, 800
C501, 505, 508, 701-708
DS1, 2, C1A/B
F1
FL1
J2, 802, 803
P1, 2, 803
Q501, 505, 509
R1
S1, 2
T1
W1
XA500

Figure 5-5

**POWER SUPPLY WIRING DIAGRAM**

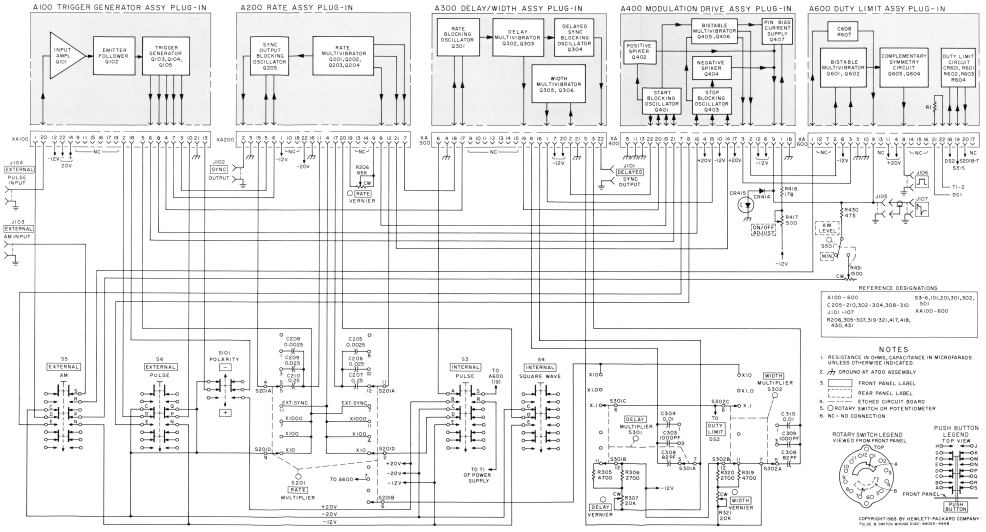



Figure 5-7. Modulation Circuit Wiring Diagram

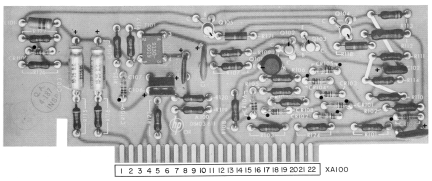



Figure 5-8. Trigger Generator Assembly (A100)

REFERENCE DESIGNATIONS

| | |
|---|---|
| A100 - 600 | S3-6,101,201,301,302, 501 |
| C209-210,302-304,308-310 | XA100-600 |
| J101-107 | |
| R204,305-307,319-321,417,418, 430,431 | |

Figure 5-7

**MODULATION CIRCUIT WIRING DIAGRAM**

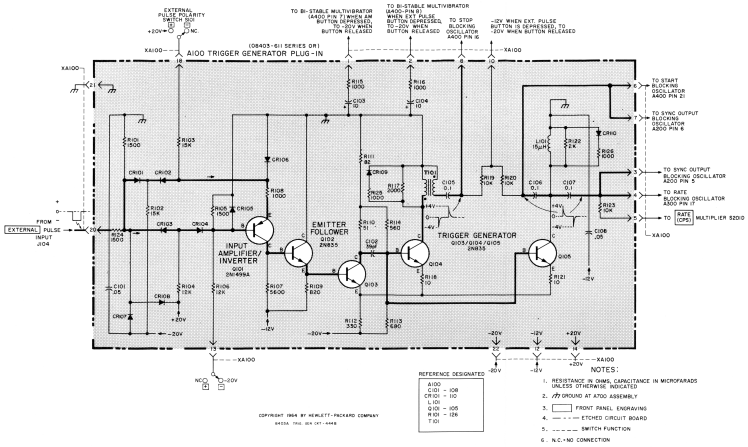

EXTERNAL PULSE POLARITY SWITCH S07
+20V
GND
-20V
TO BI-STABLE MULTIVIBRATOR (A400 PIN 7) WHEN AM BUTTON DEPRESSED; WHEN EXT PULSE BUTTON RELEASED
TO DI-STABLE MULTIVIBRATOR (A400-PIN 9) WHEN EXT PULSE BUTTON DEPRESSED; WHEN AM BUTTON RELEASED
TO STOP BLOCKING OSCILLATOR A400 PIN 16
-20V WHEN EXT PULSE BUTTON IS DEPRESSED TO -10V WHEN BUTTON RELEASED
(08403-61 SERIES OR)
A100 TRIGGER GENERATOR PLUG-IN
XA100
P1
FROM EXTERNAL PULSE INPUT J104
INPUT AMPLIFIER/ INVERTER
Q101 SN4998
EMITTER FOLLOWER
Q102 2N835
TRIGGER GENERATOR
Q103/Q104/Q105 2N835
TO START BLOCKING OSCILLATOR A400 PIN 21
TO SYNC OUTPUT BLOCKING OSCILLATOR A200 PIN 6
TO SYNC OUTPUT BLOCKING OSCILLATOR A200 PIN 5
TO RATE BLOCKING OSCILLATOR A300 PIN 17
TO RATE (CPS) MULTIPLIER 522D
REFERENCE DESIGNATES
A100
C101 - 108
CR101 - 110
L101
Q101 - 105
R101 - 126
T101
NOTES:
1. RESISTANCE IN OHMS, CAPACITANCE IN MICROFARADS UNLESS OTHERWISE INDICATED
2. GROUND AT ATTOO ASSEMBLY
3. FRONT PANEL ENGRAVING
4. ETCHED CIRCUIT BOARD
5. SWITCH FUNCTION
6. N.C.=NO CONNECTION
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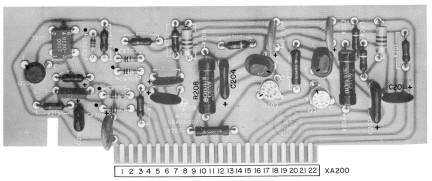
Figure 5-9. Trigger Generator Circuit




⊖ TRANSISTOR EMITTER
• ANODE
+ POSITIVE SIDE OF CAPACITOR

Figure 5-10. Rate Assembly (A200)

REFERENCE DESIGNATED
A100
C101 – 108
CR101 – 110
L101
Q101 – 105
R101 – 126
T101

Figure 5-9

**TRIGGER GENERATOR CIRCUIT SCHEMATIC DIAGRAM**

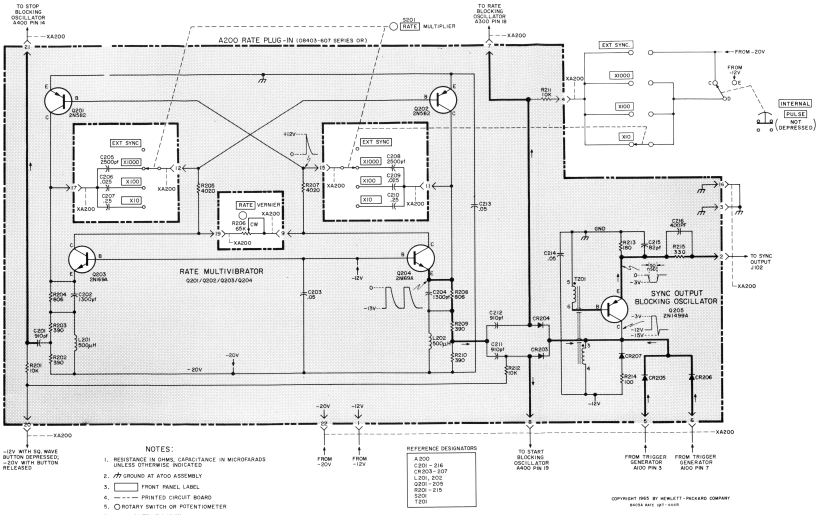
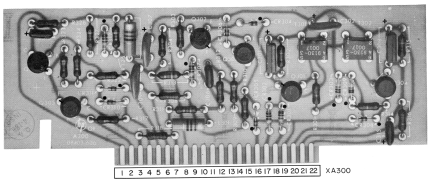



Figure 5-11. Rate Circuit




⊖ TRANSISTOR EMITTER
• ANODE
+ POSITIVE SIDE OF CAPACITOR

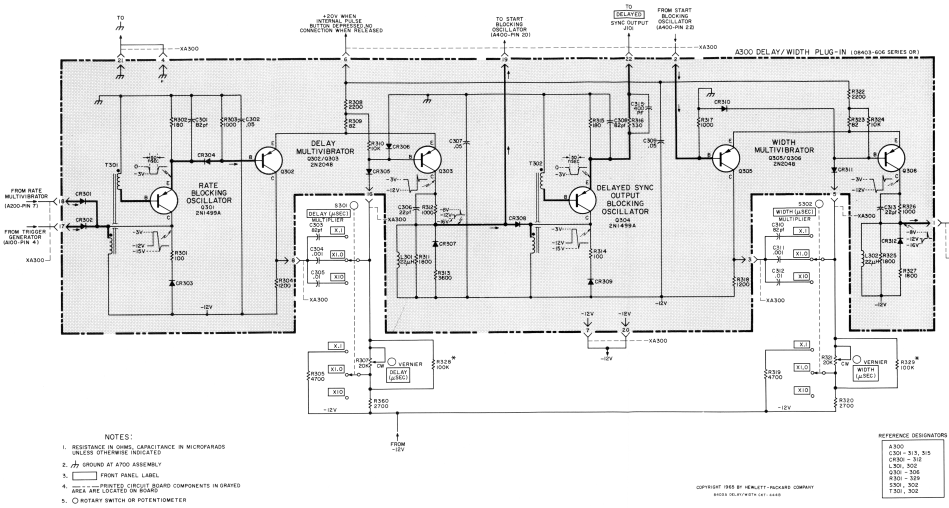
Figure 5-12. Delay/Width Assembly (A300)

REFERENCE DESIGNATORS

A 200
C 201 - 214
CR 203 - 207
L 201, 202
Q 201 - 205
R 201 - 215
T 201

Figure 5-11

**RATE CIRCUIT SCHEMATIC DIAGRAM**


A300 DELAY/WIDTH PLUG-IN (08403-606 SERIES OR)
RATE BLOCKING OSCILLATOR Q501 2N1495A
DELAY MULTIVIBRATOR Q502/Q503 2N2048
DELAYED SYNC OUTPUT BLOCKING OSCILLATOR Q504 2N1495A
WIDTH MULTIVIBRATOR Q505/Q506 2N2048
DELAY (μSEC) MULTIPLIER
WIDTH (μSEC) MULTIPLIER
VERNIER DELAY (μSEC)
VERNIER WIDTH (μSEC)
FROM RATE MULTIVIBRATOR (A200-PIN 7)
FROM TRIGGER GENERATOR (A400-PIN 41)
TO STOP BLOCKING OSCILLATOR (A400-PIN 15)
TO DELAYED SYNC OUTPUT J101
TO START BLOCKING OSCILLATOR (A400-PIN 20)
FROM START BLOCKING OSCILLATOR (A400-PIN 22)
+20V WHEN INTERNAL PULSE BUTTON IS PUSHED AND CONNECTION WHEN RELEASED
FROM −12V
XA300

NOTES:

1. RESISTANCE IN OHMS, CAPACITANCE IN MICROFARADS UNLESS OTHERWISE INDICATED.
2. ⏚ GROUND AT A700 ASSEMBLY.
3. ▭ FRONT PANEL LABEL.
4. — — — PRINTED CIRCUIT BOARD COMPONENTS IN GRAYED AREA ARE LOCATED ON BOARD.
5. ○ ROTARY SWITCH OR POTENTIOMETER.
6. ..... SWITCH FUNCTION.
7. * SELECTED VALUE, NOMINAL VALUE SHOWN, PART MAY BE OMITTED.

REFERENCE DESIGNATORS

A300
C300 - 313, 315
CR300 - 312
L300, 302
Q300 - 306
R300 - 329
T301, 302
T301, 302

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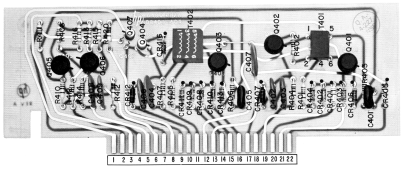
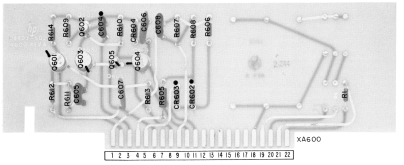
8403A DELAY/WIDTH CAT. A+400

Figure 5-13. Delay/Width Circuit



TRANSISTOR EMITTER
DIODE CATHODE

Figure 5-14. Modulator Drive Assembly (A400)



TRANSISTOR EMITTER
DIODE CATHODE

Figure 5-15. Duty Limit Assembly (A600)

REFERENCE DESIGNATORS

A300
A301 - 313, 315
CR301 - 327
L301, 302
Q301 - 306
R301 - 329
S301, 302
T301, 302

Figure 5-13
DELAY/WIDTH CIRCUIT SCHEMATIC DIAGRAM

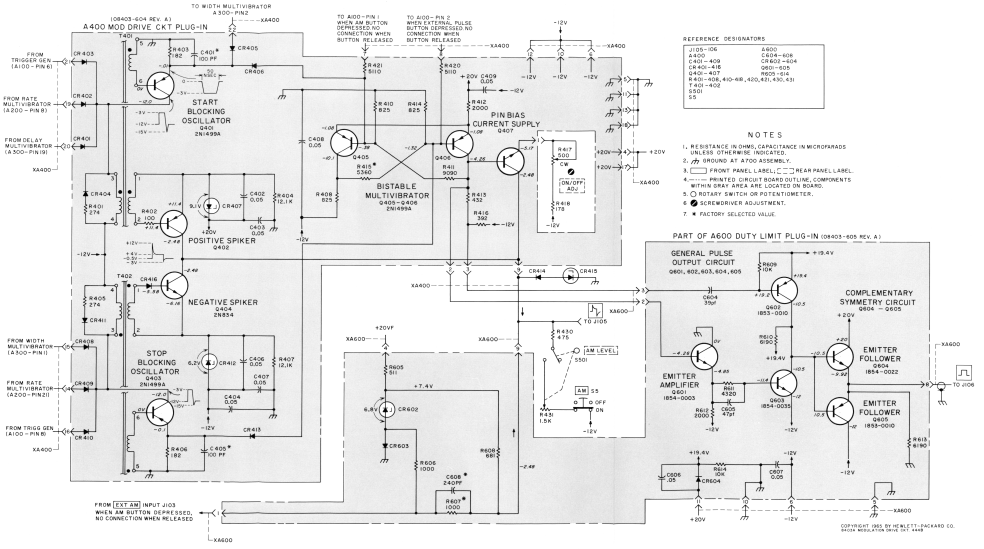
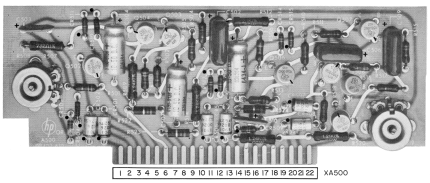

A400 MOD DRIVE CKT PLUG-IN
START BLOCKING OSCILLATOR Q401 2N4996
POSITIVE SPIKER Q402
NEGATIVE SPIKER Q404 2N834
STOP BLOCKING OSCILLATOR Q403 2N4996
PIN BIAS CURRENT SUPPLY Q407
BISTABLE MULTIVIBRATOR Q405-Q406 2N4996
PART OF A600 DUTY LIMIT PLUG-IN
GENERAL PULSE OUTPUT CIRCUIT Q601, 602, 603, 604, 605
COMPLEMENTARY SYMMETRY CIRCUIT Q604 - Q605
EMITTER AMPLIFIER Q601 1854-0003
EMITTER FOLLOWER Q606 1854-0022
EMITTER FOLLOWER Q605 1853-0010
NOTES
REFERENCE DESIGNATORS
COPYRIGHT 1965 BY HEWLETT-PACKARD CO.

Figure 5-16. Modulation Drive Circuit




○ TRANSISTOR EMITTER
• ANODE
+ POSITIVE SIDE OF CAPACITOR

Figure 5-17. Power Supply Assembly (A500)

REFERENCE DESIGNATORS

| | |
|---|---|
| J105-106 | A900 |
| A400 | C604-608 |
| C401-409 | CR602-604 |
| CR401-416 | Q601-605 |
| P401-402 | R603-614 |
| R401-408, 410-418, 420, 421, 430, 431 | |
| T401-402 | |
| S501 | |
| S5 | |

◀ Figure 5-16

**MODULATION DRIVE CIRCUIT SCHEMATIC DIAGRAM**

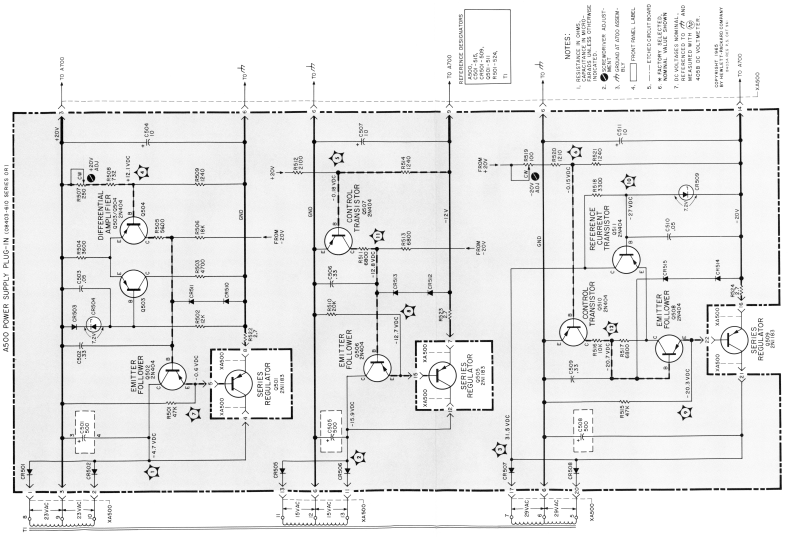



Figure 5-18. Regulated Power Supply

REFERENCE DESIGNATORS
A501,
C501 - 515,
CR501 - 509,
Q501 - 511,
R501 - 524,
T1

Figure 5-18

**REGULATED POWER SUPPLY SCHEMATIC DIAGRAM**

# SECTION VI
# REPLACEABLE PARTS

## 6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and hp stock number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their hp stock number and provides the following information on each part;

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code; see list of manufacterers in Table 6-3.

c. Manufacturer's part number.

d. Total quantity used in the instrument (TQ column).

6-3. Miscellaneous parts are listed at the end of Table 6-1.

## 6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office (see lists at rear of this manual for addresses). Identify parts by their Hewlett-Packard stock numbers.

6-6. To obtain a part that is not listed, include;

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

REFERENCE DESIGNATORS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A = assembly | F = fuse | MP = mechanical part | V = vacuum, tube, neon bulb, photocell, etc. |
| B = motor | FL = filter | P = plug | |
| BT = battery | IC = integrated circuit | Q = transistor | VR = voltage regulator |
| C = capacitor | J = jack | R = resistor | W = cable |
| CP = coupler | K = relay | RT = thermistor | X = socket |
| CR = diode | L = inductor | S = switch | Y = crystal |
| DL = delay line | LS = loud speaker | T = transformer | Z = tuned cavity, network |
| DS = device signaling (lamp) | M = meter | TB = terminal board | |
| E = misc electronic part | MK = microphone | TP = test point | |

ABBREVIATIONS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A = amperes | H = henries | N/O = normally open | RMO = rack mount only |
| AFC = automatic frequency control | HDW = hardware | NPO = negative positive zero (zero temperature coefficient) | RMS = root-mean square |
| AMPL = amplifier | HEX = hexagonal | | RWV = reverse working voltage |
| | HG = mercury | | |
| BFO = beat frequency oscillator | HR = hour(s) | NPN = negative-positive-negative | S-B = slow-blow |
| BE CU = beryllium copper | HZ = hertz | | SCR = screw |
| BH = binder head | | NRFR = not recommended for field replacement | SE = selenium |
| BP = bandpass | IF = intermediate freq | | SECT = section(s) |
| BRS = brass | IMPG = impregnated | NSR = not separately replaceable | SEMICON = semiconductor |
| BWO = backward wave oscillator | INCD = incandescent | | SI = silicon |
| | INCL = include(s) | | SIL = silver |
| CCW = counter-clockwise | INS = insulation(ed) | OBD = order by description | SL = slide |
| CER = ceramic | INT = internal | OH = oval head | SPG = spring |
| CMO = cabinet mount only | | OX = oxide | SPL = special |
| COEF = coefficient | K = kilo = 1000 | | SST = stainless steel |
| COM = common | | P = peak | SR = split ring |
| COMP = composition | LH = left hand | PC = printed circuit | STL = steel |
| COMPL = complete | LIN = linear taper | PF = picofarads = $10^{-12}$ farads | |
| CONN = connector | LK WASH = lock washer | | TA = tantalum |
| CP = cadmium plate | LOG = logarithmic taper | PH BRZ = phosphor bronze | TD = time delay |
| CRT = cathode-ray tube | LPF = low pass filter | PHL = Phillips | TGL = toggle |
| CW = clockwise | | PIV = peak inverse voltage | THD = thread |
| | M = milli = $10^{-3}$ | PNP = positive-negative-positive | TI = titanium |
| DEPC = deposited carbon | MEG = meg = $10^{6}$ | | TOL = tolerance |
| DR = drive | MET FLM = metal film | P/O = part of | TRIM = trimmer |
| | MET OX = metallic oxide | POLY = polystyrene | TWT = traveling wave tube |
| ELECT = electrolytic | MFR = manufacturer | PORC = porcelain | |
| ENCAP = encapsulated | MHZ = mega hertz | POS = position(s) | U = micro = $10^{-6}$ |
| EXT = external | MINAT = miniature | POT = potentiometer | |
| | MOM = momentary | PP = peak-to-peak | VAR = variable |
| F = farads | MTG = mounting | PT = point | VDCW = dc working volts |
| FH = flat head | MY = "mylar" | PWV = peak working voltage | |
| FIL H = fillister head | | | W/ = with |
| FXD = fixed | N = nano ($10^{-9}$) | RECT = rectifier | W = watts |
| | N/C = normally closed | RF = radio frequency | WIV = working inverse voltage |
| G = giga ($10^{9}$) | NE = neon | RH = round head or right hand | |
| GE = germanium | NI PL = nickel plate | | WW = wirewound |
| GL = glass | | | W/O = without |
| GRD = ground(ed) | | | |

01194-13

Table 6-1. Reference Designation Index

| Reference Designation | Part No. | Description # | Note |
|---|---|---|---|
| A100 | 08403-611 | BOARD ASSY:TRIGGER GENERATOR | |
| A101-A199 | | NOT ASSIGNED | |
| A200 | 08403-607 | BOARD ASSY:RATE | |
| A201 | 08403-612 | SWITCH ASSY:RATE CONTROL | |
| A201 | 5040-0218 | COUPLER:SWITCH SHAFT | |
| A201 | 3130-0056 | SHIELD:SWITCH 3/8"DIA CENTER HOLE | |
| A202-A299 | | NOT ASSIGNED | |
| A300 | 08403-606 | BOARD ASSY:DELAY/WIDTH | |
| A301 | 08403-613 | SWITCH ASSY:DELAY CONTROL | |
| A302 | 08403-614 | SWITCH ASSY:WIDTH CONTROL | |
| A303-A399 | | NOT ASSIGNED | |
| A400 | 08403-604 | BOARD ASSY:PIN DRIVER | |
| A401-A499 | | NOT ASSIGNED | |
| A500 | 08403-610 | BOARD ASSY:POWER SUPPLY | |
| A501-A599 | | NOT ASSIGNED | |
| A600 | 08403-60005 | BOARD ASSY:DUTY LIMIT | |
| A601-A699 | | NOT ASSIGNED | |
| A700 | 08403-608 | BOARD ASSY:POWER SUPPLY DISTR. | |
| C1 | 0150-0119 | C:FXD CER 2 X 0.01 UF 20% 250WVAC | |
| C1 | 0150-0119 | C:FXD CER 2 X 0.01 UF 20% 250WVAC | |
| C2-C100 | | NOT ASSIGNED | |
| C101 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C102 | 0140-0190 | C:FXD MICA 39 PF 5% | |
| C103 | 0180-0059 | C:FXD ELECT 10 UF +75-10% 25VDCW | |
| C104 | 0180-0059 | C:FXD ELECT 10 UF +75-10% 25VDCW | |
| C105 | 0150-0121 | C:FXD CER 0.1 UF +80-20% 50VDCW | |
| C106 | 0150-0121 | C:FXD CER 0.1 UF +80-20% 50VDCW | |
| C107 | 0150-0121 | C:FXD CER 0.1 UF +80-20% 50VDCW | |
| C108 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C109-C200 | | NOT ASSIGNED | |
| C201 | 0150-0113 | C:FXD CER 910 PF 5% 300VDCW | |
| C202 | 0140-0154 | C:FXD MICA 1300 PF 5% | |
| C203 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C204 | 0140-0154 | C:FXD MICA 1300 PF 5% | |
| C205 | 0160-0147 | C:FXD MICA 2500PF 2% 300VDCW | |
| C206 | 0170-0090 | C:FXD POLY 0.0252 UF 1% 50VDCW | |
| C207 | 0160-0930 | C:FXD POLY 0.25 UF 5% 50VDCW | |
| C207 | 1400-0042 | CLIP:CAPACITOR | |
| C208 | 0160-0147 | C:FXD MICA 2500PF 2% 300VDCW | |
| C209 | 0170-0090 | C:FXD POLY 0.0252 UF 1% 50VDCW | |
| C210 | 0160-0930 | C:FXD POLY 0.25 UF 5% 50VDCW | |
| C210 | 1400-0042 | CLIP:CAPACITOR | |
| C211 | 0150-0113 | C:FXD CER 910 PF 5% 300VDCW | |
| C212 | 0150-0113 | C:FXD CER 910 PF 5% 300VDCW | |
| C213 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |

# See introduction to this section for ordering information

Table 6-1. Reference Designation Index (Cont'd)

| Reference Designation | Part No. | Description # | Note |
|---|---|---|---|
| C214 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C215 | 0140-0006 | C:FXD MICA 82 PF 10% 500VDCW | |
| C216 | 0140-0177 | C:FXD MICA 400 PF 1% | |
| C217-C300 | | NOT ASSIGNED | |
| C301 | 0140-0006 | C:FXD MICA 82 PF 10% 500VDCW | |
| C302 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C303 | 0160-0145 | C:FXD MICA 82PF 2% 100VDCW | |
| C304 | 0140-0179 | C:FXD MICA 1000 PF 2% | |
| C305 | 0160-0148 | C:FXD MICA 0.01UF 2% 100VDCW | |
| C306 | 0140-0145 | C:FXD MICA 22 PF 5% | |
| C307 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C308 | 0140-0006 | C:FXD MICA 82 PF 10% 500VDCW | |
| C309 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C310 | 0160-0145 | C:FXD MICA 82PF 2% 100VDCW | |
| C311 | 0140-0179 | C:FXD MICA 1000 PF 2% | |
| C312 | 0160-0148 | C:FXD MICA 0.01UF 2% 100VDCW | |
| C313 | 0140-0145 | C:FXD MICA 22 PF 5% | |
| C314 | | NOT ASSIGNED | |
| C315 | 0140-0177 | C:FXD MICA 400 PF 1% | |
| C316-C400 | | NOT ASSIGNED | |
| C401 | 0140-0176 | C:FXD MICA 100 PF 5%(FACTORY SELECTED PART) | |
| C402 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C403 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C404 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C405 | 0140-0176 | C:FXD MICA 100 PF 5%(FACTORY SELECTED PART) | |
| C406 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C407 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C408 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C409 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C410-C500 | | NOT ASSIGNED | |
| C501 | 0180-0047 | C:FXD ELECT 500 UF 75VDCW | |
| C502 | 0170-0071 | C:FXD MY 0.33UF 20% 50VDCW | |
| C503 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C504 | 0180-0136 | C:FXD ELECT 10UF -10+100% 50VDCW | |
| C505 | 0180-0047 | C:FXD ELECT 500 UF 75VDCW | |
| C506 | 0170-0071 | C:FXD MY 0.33UF 20% 50VDCW | |
| C507 | 0180-0136 | C:FXD ELECT 10UF -10+100% 50VDCW | |
| C508 | 0180-0047 | C:FXD ELECT 500 UF 75VDCW | |
| C509 | 0170-0071 | C:FXD MY 0.33UF 20% 50VDCW | |
| C510 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C511 | 0180-0136 | C:FXD ELECT 10UF -10+100% 50VDCW | |
| C512-C600 | | NOT ASSIGNED | |
| C601 | | NOT ASSIGNED | |
| C602 | | NOT ASSIGNED | |
| C603 | | NOT ASSIGNED | |
| C604 | 0140-0190 | C:FXD MICA 39 PF 5% | |
| C605 | 0160-0939 | C:FXD MICA 430 PF 5% 300VDCW | |
| C606 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C607 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C608 C700 | | NOT ASSIGNED | |

**# See introduction to this section for ordering information**

Table 6-1. Reference Designation Index (Cont'd)

| Reference Designation | ℗ Part No. | Description # | Note |
|---|---|---|---|
| C701 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C702 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C703 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C704 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C705 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C706 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C707 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| C708 | 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | |
| CR1-CR100 | | NOT ASSIGNED | |
| CR101 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR102 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR103 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR104 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR105 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR106 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR107 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR108 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR109 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR110 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR111-CR202 | | NOT ASSIGNED | |
| CR203 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR204 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR205 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR206 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR207 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR208-CR300 | | NOT ASSIGNED | |
| CR301 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR302 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR303 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR304 | 1901-0040 | DIODE:SILICON 30MA 30WV | |
| CR305 | 1901-0040 | DIODE:SILICON 30MA 30WV | |
| CR306 | 1901-0040 | DIODE:SILICON 30MA 30WV | |
| CR307 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR308 | 1901-0040 | DIODE:SILICON 30MA 30WV | |
| CR309 | 1901-0347 | DIODE:SILICON 8V | |
| CR310 | 1901-0040 | DIODE:SILICON 30MA 30WV | |
| CR311 | 1901-0040 | DIODE:SILICON 30MA 30WV | |
| CR312 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR313-CR400 | | NOT ASSIGNED | |
| CR401 | 1901-0040 | DIODE:SILICON 30MA 30WV | |
| CR402 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR403 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR404 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR405 | 1901-0040 | DIODE:SILICON 30MA 30WV | |
| CR406 | 1901-0347 | DIODE:SILICON 8V | |
| CR407 | 1902-0037 | DIODE BREAKDOWN:9.09V 10% | |
| CR408 | 1901-0347 | DIODE:SILICON 8V | |
| CR409 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR410 | 1901-0347 | DIODE:SILICON 8V | |

**# See introduction to this section for ordering information**

Table 6-1. Reference Designation Index (Cont'd)

| Reference Designation | Part No. | Description # | Note |
|---|---|---|---|
| CR411 | 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | |
| CR412 | 1902-0036 | DIODE BREAKDOWN:6.19V 10% | |
| CR413 | 1901-0347 | DIODE:SILICON 8V | |
| CR414 | 1901-0025 | DIODE:SILICON 100WV 100MA | |
| CR415 | 1902-0126 | DIODE BREAKDOWN:2.61V 5% | |
| CR416 | 1901-0347 | DIODE:SILICON 8V | |
| CR417-CR500 | | NOT ASSIGNED | |
| CR501 | 1901-0026 | DIODE:SILICON 0.75A 200 PIV | |
| CR502 | 1901-0026 | DIODE:SILICON 0.75A 200 PIV | |
| CR503 | 1901-0025 | DIODE:SILICON 100WV 100MA | |
| CR504 | 1902-0045 | DIODE BREAKDOWN:7.32V 2% | |
| CR505 | 1901-0026 | DIODE:SILICON 0.75A 200 PIV | |
| CR506 | 1901-0026 | DIODE:SILICON 0.75A 200 PIV | |
| CR507 | 1901-0026 | DIODE:SILICON 0.75A 200 PIV | |
| CR508 | 1901-0026 | DIODE:SILICON 0.75A 200 PIV | |
| CR509 | 1902-0045 | DIODE BREAKDOWN:7.32V 2% | |
| CR510 | 1901-0039 | DIODE:SILICON 200MA 50WV | |
| CR511 | 1901-0039 | DIODE:SILICON 200MA 50WV | |
| CR512 | 1901-0039 | DIODE:SILICON 200MA 50WV | |
| CR513 | 1901-0039 | DIODE:SILICON 200MA 50WV | |
| CR514 | 1901-0039 | DIODE:SILICON 200MA 50WV | |
| CR515 | 1901-0039 | DIODE:SILICON 200MA 50WV | |
| CR516-CR600 | | NOT ASSIGNED | |
| CR601 | | NOT ASSIGNED | |
| CR602 | 1902-0048 | DIODE BREAKDOWN:6.81V 5% | |
| CR603 | 1901-0033 | DIODE:SILICON 100MA 180WV | |
| CR604 | 1901-0033 | DIODE:SILICON 100MA 180WV | |
| DS1 | 1450-0420 | LIGHT INDICATOR:A1C LAMP | |
| DS2 | 2140-0092 | LAMP:INCANDESCENT 5.0V 0.060A | |
| F1 | 2110-0201 | FUSE:CARTRIDGE 0.25 AMP SLOW BLOW(115V) | |
| F1 | 2110-0318 | FUSE:0.125A SLOW-BLOW (230V) | |
| FL1 | 9100-2887 | FILTER:LINE 50/400 HZ | |
| J1 | | NOT ASSIGNED | |
| J2 | 1251-2357 | SOCKET:3-PIN MALE POWER RECEPTACLE | |
| J3-J100 | | NOT ASSIGNED | |
| J101 | 1250-0123 | CONNECTOR:RECEPTACLE | |
| J102 | 1250-0123 | CONNECTOR:RECEPTACLE | |
| J103 | 1250-0123 | CONNECTOR:RECEPTACLE | |
| J104 | 1250-0123 | CONNECTOR:RECEPTACLE | |
| J105 | 1250-0123 | CONNECTOR:RECEPTACLE | |
| J106 | 1250-0253 | CONNECTOR:RF BNC JACK | |
| J107 | 1250-0253 | CONNECTOR:RF BNC JACK | |
| L1-L100 | | NOT ASSIGNED | |
| L101 | 9140-0082 | COIL:FXD RF 15 UH | |
| L102-L200 | | NOT ASSIGNED | |
| L201 | 9140-0118 | COIL:FXD 500 UH 5% | |

**# See introduction to this section for ordering information**

Table 6-1. Reference Designation Index (Cont'd)

| Reference Designation | Part No. | Description # | Note |
|---|---|---|---|
| L202 | 9140-0118 | COIL:FXD 500 UH 5% | |
| L203- | | | |
| L300 | | NOT ASSIGNED | |
| L301 | 9140-0115 | COIL:FXD RF 22 UH 10% | |
| L302 | 9140-0115 | COIL:FXD RF 22 UH 10% | |
| P1 | | NSR PART OF W1 | |
| P2 | | NSR PART OF W1 | |
| Q1- | | | |
| Q100 | | NOT ASSIGNED | |
| Q101 | 1850-0093 | TRANSISTOR:GERMANIUM 2N1499A PNP | |
| Q102 | 1854-0011 | TRANSISTOR:2N835 NPN SILICON | |
| Q103 | 1854-0011 | TRANSISTOR:2N835 NPN SILICON | |
| Q104 | 1854-0011 | TRANSISTOR:2N835 NPN SILICON | |
| Q105 | 1854-0011 | TRANSISTOR:2N835 NPN SILICON | |
| Q106- | | | |
| Q200 | | NOT ASSIGNED | |
| Q201 | 1850-0101 | TRANSISTOR:SPL2N582 | |
| Q202 | 1850-0101 | TRANSISTOR:SPL2N582 | |
| Q203 | 1851-0023 | TRANSISTOR:GERMANIUM NPN | |
| Q204 | 1851-0023 | TRANSISTOR:GERMANIUM NPN | |
| Q205 | 1850-0093 | TRANSISTOR:GERMANIUM 2N1499A PNP | |
| Q206- | | | |
| Q300 | | NOT ASSIGNED | |
| Q301 | 1850-0093 | TRANSISTOR:GERMANIUM 2N1499A PNP | |
| Q302 | 1850-0091 | TRANSISTOR:GERMANIUM 2N2048 PNP | |
| Q303 | 1850-0091 | TRANSISTOR:GERMANIUM 2N2048 PNP | |
| Q304 | 1850-0093 | TRANSISTOR:GERMANIUM 2N1499A PNP | |
| Q305 | 1850-0091 | TRANSISTOR:GERMANIUM 2N2048 PNP | |
| Q306 | 1850-0091 | TRANSISTOR:GERMANIUM 2N2048 PNP | |
| Q307- | | | |
| Q400 | | NOT ASSIGNED | |
| Q401 | 1850-0093 | TRANSISTOR:GERMANIUM 2N1499A PNP | |
| Q402 | 1850-0105 | TRANSISTOR:GERMANIUM PNP SPL 2N2048 | |
| Q403 | 1850-0093 | TRANSISTOR:GERMANIUM 2N1499A PNP | |
| Q404 | 1854-0010 | TRANSISTOR:2N834 NPN SILICON | |
| Q405 | 1850-0093 | TRANSISTOR:GERMANIUM 2N1499A PNP | |
| Q406 | 1850-0093 | TRANSISTOR:GERMANIUM 2N1499A PNP | |
| Q407 | 1854-0003 | TRANSISTOR:NPN SILICON | |
| Q408- | | | |
| Q500 | | NOT ASSIGNED | |
| Q501 | 1850-0064 | TRANSISTOR:GERMANIUM PNP 2N1183 | |
| Q501 | 0340-0487 | INSULATOR:TRANSISTOR | |
| Q501 | 1200-0087 | CLAMP:TRANSISTOR | |
| Q501 | 08403-20001 | BUSHING:TRANSISTOR | |
| Q502 | 1850-0062 | TRANSISTOR:GERMANIUM ALLOY JUNCTION | |
| Q503 | 1850-0062 | TRANSISTOR:GERMANIUM ALLOY JUNCTION | |
| Q504 | 1850-0062 | TRANSISTOR:GERMANIUM ALLOY JUNCTION | |
| Q505 | 1850-0064 | TRANSISTOR:GERMANIUM PNP 2N1183 | |
| Q505 | 0340-0487 | INSULATOR:TRANSISTOR | |
| Q505 | 1200-0087 | CLAMP:TRANSISTOR | |
| Q505 | 08403-20001 | BUSHING:TRANSISTOR | |
| Q506 | 1850-0062 | TRANSISTOR:GERMANIUM ALLOY JUNCTION | |
| Q507 | 1850-0062 | TRANSISTOR:GERMANIUM ALLOY JUNCTION | |
| Q508 | 1850-0062 | TRANSISTOR:GERMANIUM ALLOY JUNCTION | |

**# See introduction to this section for ordering information**

Table 6-1. Reference Designation Index (Cont'd)

| Reference Designation | hp Part No. | Description # | Note |
|---|---|---|---|
| Q509 | 1850-0064 | TRANSISTOR:GERMANIUM PNP 2N1183 | |
| Q509 | 0340-0487 | INSULATOR:TRANSISTOR | |
| Q509 | 1200-0087 | CLAMP:TRANSISTOR | |
| Q509 | 08403-20001 | BUSHING:TRANSISTOR | |
| Q510 | 1850-0062 | TRANSISTOR:GERMANIUM ALLOY JUNCTION | |
| Q511 | 1850-0062 | TRANSISTOR:GERMANIUM ALLOY JUNCTION | |
| Q512-Q600 | | NOT ASSIGNED | |
| Q601 | 1854-0003 | TRANSISTOR:NPN SILICON | |
| Q602 | 1854-0003 | TRANSISTOR:NPN SILICON | |
| Q603 | 1854-0035 | TRANSISTOR:NPN SILICON | |
| Q604 | 1854-0022 | TRANSISTOR:NPN SILICON | |
| Q605 | 1853-0010 | TRANSISTOR:SILICON PNP | |
| R1 | 0757-0454 | R:FXD MET FLM 33.2K OHM 1% 1/8W | |
| R2 | 0686-1115 | R:FXD COMP 110 OHM 5% 1/2W | |
| R3-R100 | | NOT ASSIGNED | |
| R101 | 0758-0017 | R:FXD MET OX 1500 OHM 5% 1/2W | |
| R102 | 0758-0018 | R:FXD MET OX 15K OHM 5% 1/2W | |
| R103 | 0758-0018 | R:FXD MET OX 15K OHM 5% 1/2W | |
| R104 | 0758-0012 | R:FXD MET OX 12K OHM 5% 1/2W | |
| R105 | 0758-0017 | R:FXD MET OX 1500 OHM 5% 1/2W | |
| R106 | 0758-0012 | R:FXD MET OX 12K OHM 5% 1/2W | |
| R107 | 0758-0057 | R:FXD MET OX 5600 OHM 5% 1/2W | |
| R108 | 0758-0003 | R:FXD MET OX 1000 OHM 5% 1/2W | |
| R109 | 0758-0032 | R:FXD MET OX 820 OHM 5% 1/2W | |
| R110 | 0757-0086 | R:FXD FLM 51 OHM 2% 1/4W | |
| R111 | 0758-0026 | R:FXD MET OX 82 OHM 5% 1/2W | |
| R112 | 0760-0022 | R:FXD MET FLM 330 OHM 2% 1W | |
| R113 | 0757-0126 | R:FXD FLM 680 OHM 2% 1/4W | |
| R114 | 0758-0002 | R:FXD MET OX FLM 560 OHM 5% 1/2W | |
| R115 | 0758-0046 | R:FXD MET OX 6200 OHM 5% 1/2W | |
| R116 | 0758-0046 | R:FXD MET OX 6200 OHM 5% 1/2W | |
| R117 | 0758-0033 | R:FXD MET OX 2000 OHM 5% 1/2W | |
| R118 | 0686-1005 | R:FXD COMP 10 OHM 5% 1/2W | |
| R119 | 0758-0006 | R:FXD MET OX 10K OHM 5% 1/2W | |
| R120 | 0758-0006 | R:FXD MET OX 10K OHM 5% 1/2W | |
| R121 | 0686-1005 | R:FXD COMP 10 OHM 5% 1/2W | |
| R122 | 0758-0033 | R:FXD MET OX 2000 OHM 5% 1/2W | |
| R123 | 0758-0006 | R:FXD MET OX 10K OHM 5% 1/2W | |
| R124 | 0758-0017 | R:FXD MET OX 1500 OHM 5% 1/2W | |
| R125 | 0758-0003 | R:FXD MET OX 1000 OHM 5% 1/2W | |
| R126 | 0758-0003 | R:FXD MET OX 1000 OHM 5% 1/2W | |
| R127-R200 | | NOT ASSIGNED | |
| R201 | 0758-0006 | R:FXD MET OX 10K OHM 5% 1/2W | |
| R202 | 0758-0008 | R:FXD MET OX FLM 390 OHM 5% 1/2W | |
| R203 | 0758-0008 | R:FXD MET OX FLM 390 OHM 5% 1/2W | |
| R204 | 0760-0011 | R:FXD MET OX 806 OHM 1% 1W | |
| R205 | 0757-0085 | R:FXD MET FLM 4020 OHM 1% 1/2W | |
| R206 | 2100-0434 | R:VAR COMP 65K OHM 10% LIN 2.25W | |
| R207 | 0757-0085 | R:FXD MET FLM 4020 OHM 1% 1/2W | |
| R208 | 0760-0011 | R:FXD MET OX 806 OHM 1% 1W | |
| R209 | 0758-0008 | R:FXD MET OX FLM 390 OHM 5% 1/2W | |
| R210 | 0758-0008 | R:FXD MET OX FLM 390 OHM 5% 1/2W | |

**# See introduction to this section for ordering information**

Table 6-1. Reference Designation Index (Cont'd)

| Reference Designation | Part No. | Description # | Note |
|---|---|---|---|
| R211 | 0758-0006 | R:FXD MET OX 10K OHM 5% 1/2W | |
| R212 | 0758-0006 | R:FXD MET OX 10K OHM 5% 1/2W | |
| R213 | 0758-0014 | R:FXD MET FLM 180 OHM 5% 1/2W | |
| R214 | 0758-0024 | R:FXD MET OX 100 OHM 5% 1/2W | |
| R215 | 0758-0054 | R:FXD MET OX 330 OHM 5% 1/2W | |
| R216-R300 | | NOT ASSIGNED | |
| R301 | 0758-0024 | R:FXD MET OX 100 OHM 5% 1/2W | |
| R302 | 0758-0014 | R:FXD MET FLM 180 OHM 5% 1/2W | |
| R303 | 0758-0003 | R:FXD MET OX 1000 OHM 5% 1/2W | |
| R304 | 0757-0077 | R:FXD FLM 1.2K OHM 2% 1/4W | |
| R305 | 0757-0080 | R:FXD FLM 4700 OHM 2% 1/4W | |
| R306 | 0757-0079 | R:FXD FLM 2.7K OHM 2% 1/4W | |
| R307 | 2100-0433 | R:VAR COMP 20K OHM 10% LIN 2.25W | |
| R308 | 0757-0078 | R:FXD FLM 2.2K OHM 2% 1/4W | |
| R309 | 0758-0026 | R:FXD MET OX 82 OHM 5% 1/2W | |
| R310 | 0758-0006 | R:FXD MET OX 10K OHM 5% 1/2W | |
| R311 | 0758-0043 | R:FXD MET OX 1800 OHM 5% 1/2W | |
| R312 | 0758-0003 | R:FXD MET OX 1000 OHM 5% 1/2W | |
| R313 | 0758-0036 | R:FXD MET OX 3600 OHM 5% 1/2W | |
| R314 | 0758-0024 | R:FXD MET OX 100 OHM 5% 1/2W | |
| R315 | 0758-0014 | R:FXD MET FLM 180 OHM 5% 1/2W | |
| R316 | 0758-0054 | R:FXD MET OX 330 OHM 5% 1/2W | |
| R317 | 0758-0003 | R:FXD MET OX 1000 OHM 5% 1/2W | |
| R318 | 0757-0077 | R:FXD FLM 1.2K OHM 2% 1/4W | |
| R319 | 0757-0080 | R:FXD FLM 4700 OHM 2% 1/4W | |
| R320 | 0757-0079 | R:FXD FLM 2.7K OHM 2% 1/4W | |
| R321 | 2100-0433 | R:VAR COMP 20K OHM 10% LIN 2.25W | |
| R322 | 0757-0078 | R:FXD FLM 2.2K OHM 2% 1/4W | |
| R323 | 0758-0026 | R:FXD MET OX 82 OHM 5% 1/2W | |
| R324 | 0758-0006 | R:FXD MET OX 10K OHM 5% 1/2W | |
| R325 | 0758-0043 | R:FXD MET OX 1800 OHM 5% 1/2W | |
| R326 | 0758-0003 | R:FXD MET OX 1000 OHM 5% 1/2W | |
| R327 | 0758-0043 | R:FXD MET OX 1800 OHM 5% 1/2W | |
| R328 | 0687-1041 | R:FXD COMP 100K OHM 10% 1/2W | |
| R329 | 0687-1041 | R:FXD COMP 100K OHM 10% 1/2W | |
| R330-R400 | | NOT ASSIGNED | |
| R401 | 0757-0409 | R:FXD MET OX 274 OHM 1% 1/8W | |
| R402 | 0757-0401 | R:FXD MET FLM 100 OHM 1% 1/8W | |
| R403 | 0757-0406 | R:FXD MET FLM 182 OHM 1% 1/8W | |
| R404 | 0757-0444 | R:FXD MET FLM 12.1K OHM 1% 1/8W | |
| R405 | 0757-0409 | R:FXD MET OX 274 OHM 1% 1/8W | |
| R406 | 0757-0406 | R:FXD MET FLM 182 OHM 1% 1/8W | |
| R407 | 0757-0444 | R:FXD MET FLM 12.1K OHM 1% 1/8W | |
| R408 | 0757-0421 | R:FXD MET FLM 825 OHM 1% 1/8W | |
| R409 | | NOT ASSIGNED | |
| R410 | 0757-0421 | R:FXD MET FLM 825 OHM 1% 1/8W | |
| R411 | 0757-0288 | R:FXD MET FLM 9.09K OHM 1% 1/8W | |
| R412 | 0757-0283 | R:FXD MET FLM 2.00K OHM 1% 1/8W | |
| R413 | 0757-0414 | R:FXD FLM 432 OHM 1% 1/8W | |
| R414 | 0757-0421 | R:FXD MET FLM 825 OHM 1% 1/8W | |
| R415 | 0698-3258 | R:FXD MET FLM 5.36K OHM 1% 1/8W | |
| R416 | 0757-0413 | R:FXD MET FLM 392 OHM 1% 1/8W | |
| R417 | 2100-0019 | R:VAR COMP 500 OHM 10% LIN 1/2W | |
| R418 | 0698-3334 | R:FXD MET FLM 178 OHM 1% 1/2W | |

**# See introduction to this section for ordering information**

Table 6-1. Reference Designation Index (Cont'd)

| Reference Designation | Part No. | Description # | Note |
|---|---|---|---|
| R419 | | NOT ASSIGNED | |
| R420 | 0757-0438 | R:FXD MET FLM 5.11K OHM 1% 1/8W | |
| R421 | 0757-0438 | R:FXD MET FLM 5.11K OHM 1% 1/8W | |
| R422-R429 | | NOT ASSIGNED | |
| R430 | 0757-0725 | R:FXD MET FLM 475 OHM 1% 1/4W | |
| R431 | 2100-0350 | R:VAR COMP 1500 OHM 20% LIN 1/2W | |
| R432-R500 | | NOT ASSIGNED | |
| R501 | 0758-0040 | R:FXD MET OX 47K OHM 5% 1/2W | |
| R502 | 0758-0012 | R:FXD MET OX 12K OHM 5% 1/2W | |
| R503 | 0758-0005 | R:FXD MET OX 4700 OHM 5% 1/2W | |
| R504 | 0758-0036 | R:FXD MET OX 3600 OHM 5% 1/2W | |
| R505 | 0758-0057 | R:FXD MET OX 5600 OHM 5% 1/2W | |
| R506 | 0758-0019 | R:FXD MET OX 18K OHM 5% 1/2W | |
| R507 | 2100-0128 | R:VAR COMP 250 OHM 20% LIN 1/3W | |
| R508 | 0757-0081 | R:FXD MET FLM 732 OHM 1% 1/2W | |
| R509 | 0757-0083 | R:FXD MET FLM 1240 OHM 1% 1/2W | |
| R510 | 0758-0039 | R:FXD MET OX 20K OHM 5% 1/2W | |
| R511 | 0758-0009 | R:FXD MET OX 6800 OHM 5% 1/2W | |
| R512 | 0757-0084 | R:FXD MET FLM 2100 OHM 1% 1/2W | |
| R513 | 0758-0009 | R:FXD MET OX 6800 OHM 5% 1/2W | |
| R514 | 0757-0083 | R:FXD MET FLM 1240 OHM 1% 1/2W | |
| R515 | 0758-0040 | R:FXD MET OX 47K OHM 5% 1/2W | |
| R516 | 0758-0006 | R:FXD MET OX 10K OHM 5% 1/2W | |
| R517 | 0758-0009 | R:FXD MET OX 6800 OHM 5% 1/2W | |
| R518 | 0758-0010 | R:FXD MET OX FLM 3300 OHM 5% 1/2W | |
| R519 | 2100-0108 | R:VAR COMP LIN 100 OHM 0% 1/3W | |
| R520 | 0757-0082 | R:FXD MET FLM 1210 OHM 1% 1/2W | |
| R521 | 0757-0083 | R:FXD MET FLM 1240 OHM 1% 1/2W | |
| R522 | 0699-0001 | R:FXD COMP 2.7 OHM 10% 1/2W | |
| R523 | 0699-0001 | R:FXD COMP 2.7 OHM 10% 1/2W | |
| R524 | 0699-0001 | R:FXD COMP 2.7 OHM 10% 1/2W | |
| R525-R600 | | NOT ASSIGNED | |
| R601 | | NOT ASSIGNED | |
| R602 | | NOT ASSIGNED | |
| R603 | | NOT ASSIGNED | |
| R604 | | NOT ASSIGNED | |
| R605 | 0757-0726 | R:FXD MET FLM 511 OHM 1% 1/4W | |
| R606 | 0757-0280 | R:FXD MET FLM 1K OHM 1% 1/8W | |
| R607 | 0757-0280 | R:FXD MET FLM 1K OHM 1% 1/8W | |
| R608 | 0757-0419 | R:FXD MET FLM 681 OHM 1% 1/8W | |
| R609 | 0757-0489 | R:FXD MET FLM 10 OHM 1% 1/4W | |
| R610 | 0757-0290 | R:FXD MET FLM 6.19K OHM 1% 1/8W | |
| R611 | 0757-0436 | R:FXD MET FLM 4.32K OHM 1% 1/8W | |
| R612 | 0757-0283 | R:FXD MET FLM 2.00K OHM 1% 1/8W | |
| R613 | 0757-0290 | R:FXD MET FLM 6.19K OHM 1% 1/8W | |
| R614 | 0757-0442 | R:FXD MET FLM 10.0K OHM 1% 1/8W | |
| S1 | 3104-0004 | SWITCH: MULTI PUSH 5 UNIT | |
| S2 | 3101-1234 | SWITCH:SLIDE DPDT 6A 250 VAC | |
| S3 | 3104-0004 | SWITCH: MULTI PUSH 5 UNIT | |
| S4 | 3104-0004 | SWITCH: MULTI PUSH 5 UNIT | |
| S5 | 3104-0004 | SWITCH: MULTI PUSH 5 UNIT | |

**# See introduction to this section for ordering information**

Table 6-1. Reference Designation Index (Cont'd)

| Reference Designation | ℗ Part No. | Description # | Note |
|---|---|---|---|
| S6 | 3104-0004 | SWITCH: MULTI PUSH 5 UNIT | |
| S7- | | | |
| S100 | | NOT ASSIGNED | |
| S101 | 3101-0011 | SWITCH:SLIDE DPDT | |
| S102- | | | |
| S200 | | NOT ASSIGNED | |
| S201 | | NSR PART OF A201 | |
| S202- | | | |
| S300 | | NOT ASSIGNED | |
| S301 | | NSR PART OF A301 | |
| S302 | | NSR PART OF A302 | |
| S303- | | | |
| S500 | | NOT ASSIGNED | |
| S501 | | NSR PART OF R431 | |
| T1 | 9100-0161 | TRANSFORMER:POWER | |
| T2- | | | |
| T100 | | NOT ASSIGNED | |
| T101 | 9130-0019 | TRANSFORMER:PULSE 1:1 TURNS RATIO | |
| T102- | | | |
| T200 | | NOT ASSIGNED | |
| T201 | 9100-0373 | TRANSFORMER:PULSE TURN RATIO 1:3:1 | |
| T202- | | | |
| T300 | | NOT ASSIGNED | |
| T301 | 9100-0373 | TRANSFORMER:PULSE TURN RATIO 1:3:1 | |
| T302 | 9100-0373 | TRANSFORMER:PULSE TURN RATIO 1:3:1 | |
| T303- | | | |
| T400 | | NOT ASSIGNED | |
| T401 | 9130-0017 | TRANSFORMER:PULSE TURNS RATIO 1:3:1 | |
| T402 | 9130-0017 | TRANSFORMER:PULSE TURNS RATIO 1:3:1 | |
| W1 | 8120-1348 | CABLE ASSY:POWER CORD | |
| XA100 | 1251-0172 | CONNECTOR:PRINTED CIRCUIT 22-CONN | |
| XA101- | | | |
| XA199 | | NOT ASSIGNED | |
| XA200 | 1251-0172 | CONNECTOR:PRINTED CIRCUIT 22-CONN | |
| XA201- | | | |
| XA299 | | NOT ASSIGNED | |
| XA300 | 1251-0172 | CONNECTOR:PRINTED CIRCUIT 22-CONN | |
| XA301- | | | |
| XA399 | | NOT ASSIGNED | |
| XA400 | 1251-0172 | CONNECTOR:PRINTED CIRCUIT 22-CONN | |
| XA401- | | | |
| XA499 | | NOT ASSIGNED | |
| XA500 | 1251-0172 | CONNECTOR:PRINTED CIRCUIT 22-CONN | |
| XA501- | | | |
| XA599 | | NOT ASSIGNED | |
| XA600 | 1251-0172 | CONNECTOR:PRINTED CIRCUIT 22-CONN | |
| XF1 | 1400-0084 | FUSEHOLDER:EXTRACTOR POST TYPE | |
| | | MISCELLANEOUS | |
| | 08403-609 | BOARD ASSY:EXTENDER | |
| | 08403-005 | BRACKET:BOARD EXTENDER | |
| | 1410-0052 | BUSHING:POTENTIOMETER | |
| | 08403-602 | CABLE ASSY:PATCH | |
| | 08403-603 | CABLE ASSY:SHIELDED | |
| | 08403-60006 | CABLE ASSY:AC | |

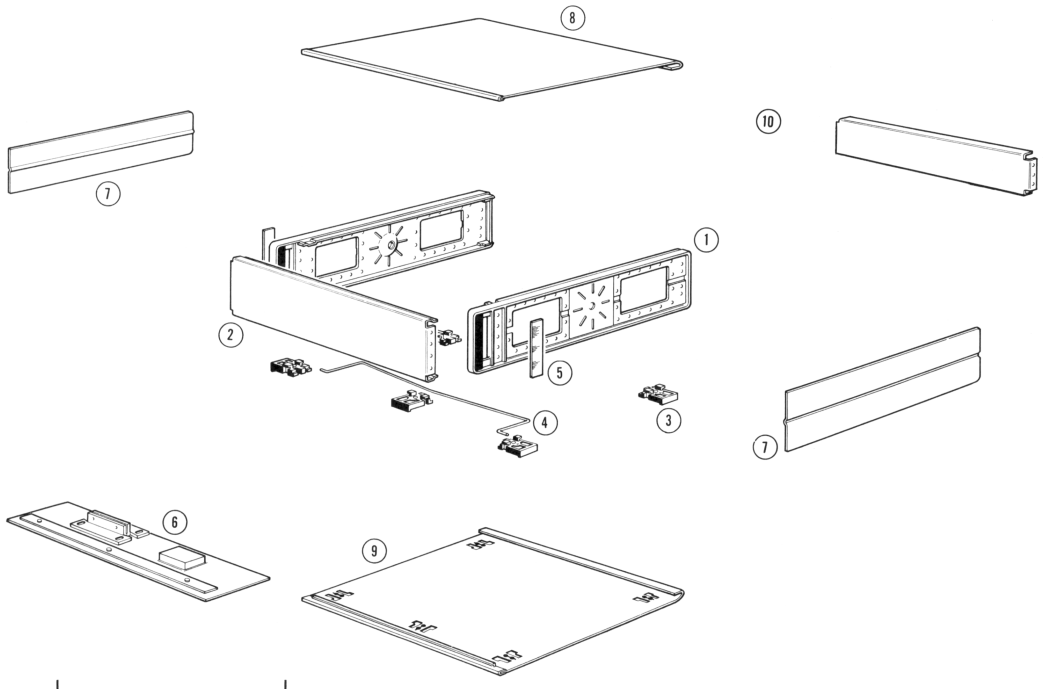
**# See introduction to this section for ordering information**

Table 6-1. Reference Designation Index (Cont'd)

| Reference Designation | Part No. | Description # | Note |
|---|---|---|---|
| | | MISCELLANEOUS(CONT'D) | |
| | 5040-0218 | COUPLER:SWITCH SHAFT | |
| | 0510-0123 | FASTENER:PUSH-ON TYPE | |
| | 08403-011 | KNOB:DELAY/WIDTH | |
| | 08403-010 | KNOB:DELAY/WIDTH | |
| | 08403-008 | KNOB:RATE | |
| | 08403-009 | KNOB:RATE(VERNIER) | |
| | 08403-011 | KNOB:DELAY/WIDTH | |
| | 0370-0103 | KNOB:BLK W/ARROW 5/8" OD 1/4" SHAFT AM LEVEL | |
| | 0370-0118 | PUSHBUTTON:LIGHT GRAY | |
| | 0370-1400 | PUSHBUTTON:JADE GRAY(DARK GRAY) | |
| | 5000-0245 | LABEL:PULSE | |
| | 5000-0246 | LABEL:SQUARE WAVE | |
| | 5000-0248 | LABEL:LINE | |
| | 5000-0249 | LABEL:AM | |
| | 1520-0001 | PLATE:MOUNTING ELECTROLYTIC CAPACITOR | |
| | 08403-006 | PLATE:SWITCH MOUNTING | |
| | 3130-0056 | SHIELD:SWITCH 3/8"DIA CENTER HOLE | |
| | 7122-0082 | SERIAL PLATE(115/230 VOLTS,50-400CYCLE) | |
| | 0460-0105 | TAPE:POLYURETHANE,GRAY | |

**# See introduction to this section for ordering information**

Table 6-1. Reference Designation Index (Cont'd)

| Reference Designation | Part No. | Description # | Note |
|---|---|---|---|
| | | **Cabinet Parts** | |
| | |  | |
| 1 | 5060-0730 | **ASSY:FRAME** | |
| 2 | 08403-00021 | PANEL:FRONT, LIGHT GRAY | |
| | 08403-00023 | **PANEL:FRONT**, MINT GRAY(WHITE GRAY) | |
| 3 | 5060-0767 | **FOOT ASSY:FM** | |
| 4 | 1490-0030 | **STAND:TILT** | |
| 5 | 5000-0050 | TRIM:SIDE | |
| 6 | 5060-0774 | KIT:RACK MOUNT, LIGHT GRAY | |
| | 5060-8739 | **KIT:RACK MOUNT**, MINT GRAY(WHITE GRAY) | |
| 7 | 5000-0731 | **COVER:SIDE PERFORATED**, BLUE GRAY | |
| | 5000-8595 | COVER:SIDE PERFORATED, OLIVE GRAY | |
| 8 | 5060-0740 | **TOP COVER ASSY:16L FM**, BLUE GRAY | |
| | 5060-8589 | TOP COVER ASSY:16L FM, OLIVE GRAY | |
| 9 | 5060-0752 | **BOTTOM COVER ASSY:16L FM**, BLUE GRAY | |
| | 5060-8613 | BOTTOM COVER ASSY:16L FM, OLIVE GRAY | |
| 10 | 08403-00022 | **PANEL:REAR** | |

**# See introduction to this section for ordering information**

Table 6-2. Replaceable Parts

| Part No. | Description # | Mfr. | Mfr. Part No. | TQ |
|---|---|---|---|---|
| 0140-0006 | C:FXD MICA 82 PF 10% 500VDCW | 28480 | 0140-0006 | 3 |
| 0140-0145 | C:FXD MICA 22 PF 5% | 28480 | 0140-0145 | 2 |
| 0140-0154 | C:FXD MICA 1300 PF 5% | 28480 | 0140-0154 | 2 |
| 0140-0177 | C:FXD MICA 400 PF 1% | 28480 | 0140-0177 | 2 |
| 0140-0179 | C:FXD MICA 1000 PF 2% | 28480 | 0140-0179 | 2 |
| 0140-0190 | C:FXD MICA 39 PF 5% | 28480 | 0140-0190 | 2 |
| 0140-0176 | C:FXD MICA 100 PF 5% | 28480 | 0140-0176 | 2 |
| 0150-0113 | C:FXD CER 910 PF 5% 300VDCW | 71590 | DA162-144J | 3 |
| 0150-0119 | C:FXD CER 2 X 0.01 UF 20% 250WVAC | 56289 | 36C219A | 1 |
| 0150-0121 | C:FXD CER 0.1 UF +80-20% 50VDCW | 56289 | 5C50BIS-CML | 3 |
| 0160-0145 | C:FXD MICA 82PF 2% 100VDCW | 04062 | RDM15E820G6S | 2 |
| 0160-0147 | C:FXD MICA 2500PF 2% 300VDCW | 04062 | RDM20F252G3S | 2 |
| 0160-0148 | C:FXD MICA 0.01UF 2% 100VDCW | 04062 | RDM30F103G1S | 2 |
| 0160-0930 | C:FXD POLY 0.25 UF 5% 50VDCW | 56289 | 114P2545R5S4-PYP | 2 |
| 0160-0939 | C:FXD MICA 430 PF 5% 300VDCW | 28480 | 0160-0939 | 1 |
| 0160-2917 | C:FXD CER 0.05 UF +80-20% 100VDCW | 84411 | TYPE TA | 27 |
| 0170-0071 | C:FXD MY 0.33UF 20% 50VDCW | 84411 | TYPE 602 SPECIAL | 3 |
| 0170-0090 | C:FXD POLY 0.0252 UF 1% 50VDCW | 56289 | P246505 PYP | 2 |
| 0180-0047 | C:FXD ELECT 500 UF 75VDCW | 56289 | D32443 DFP | 3 |
| 0180-0059 | C:FXD ELECT 10 UF +75-10% 25VDCW | 28480 | 0180-0059 | 2 |
| 0180-0136 | C:FXD ELECT 10UF -10+100% 50VDCW | 56289 | 40D106F050DC4M1 | 3 |
| 0340-0487 | INSULATOR:TRANSISTOR | 76530 | 293233 | 3 |
| 0370-0103 | KNOB:BLACK W/ARROW 5/8"OD 1/4" SHAFT | 28480 | 0370-0103 | 1 |
| 0370-0118 | KNOB:PUSHBUTTON, LIGHT GRAY | 28480 | 0370-0118 | 1 |
| 0370-1400 | KNOB:PUSHBUTTON, JADE GRAY(DARK GRAY) | 28480 | 0370-1400 | 1 |
| 0510-0123 | FASTENER:PUSH-ON TYPE | 78553 | C12008-014-4 | 1 |
| 0590-0053 | NUT:CAPTIVE 6-32 GOLD CHROMATE | 00000 | OBD | 1 |
| 0686-1005 | R:FXD COMP 10 OHM 5% 1/2W | 01121 | EB 1005 | 2 |
| 0687-1041 | R:FXD COMP 100K OHM 10% 1/2W | 01121 | EB 1041 | 2 |
| 0698-3258 | R:FXD MET FLM 5.36K OHM 1% 1/8W | 28480 | 0698-3258 | 1 |
| 0698-3334 | R:FXD MET FLM 178 OHM 1% 1/2W | 28480 | 0698-3334 | 1 |
| 0699-0001 | R:FXD COMP 2.7 OHM 10% 1/2W | 01121 | EB 27G1 | 3 |
| 0757-0077 | R:FXD FLM 1.2K OHM 2% 1/4W | 28480 | 0757-0077 | 2 |
| 0757-0078 | R:FXD FLM 2.2K OHM 2% 1/4W | 28480 | 0757-0078 | 2 |
| 0757-0079 | R:FXD FLM 2.7K OHM 2% 1/4W | 28480 | 0757-0079 | 2 |
| 0757-0080 | R:FXD FLM 4700 OHM 2% 1/4W | 28480 | 0757-0080 | 2 |
| 0757-0081 | R:FXD MET FLM 732 OHM 1% 1/2W | 28480 | 0757-0081 | 1 |
| 0757-0082 | R:FXD MET FLM 1210 OHM 1% 1/2W | 28480 | 0757-0082 | 1 |
| 0757-0083 | R:FXD MET FLM 1240 OHM 1% 1/2W | 28480 | 0757-0083 | 3 |
| 0757-0084 | R:FXD MET FLM 2100 OHM 1% 1/2W | 28480 | 0757-0084 | 1 |
| 0757-0085 | R:FXD MET FLM 4020 OHM 1% 1/2W | 28480 | 0757-0085 | 2 |
| 0757-0086 | R:FXD FLM 51 OHM 2% 1/4W | 28480 | 0757-0086 | 1 |
| 0757-0126 | R:FXD FLM 680 OHM 2% 1/4W | 28480 | 0757-0126 | 1 |
| 0757-0280 | R:FXD MET FLM 1K OHM 1% 1/8W | 28480 | 0757-0280 | 2 |
| 0757-0283 | R:FXD MET FLM 2.00K OHM 1% 1/8W | 28480 | 0757-0283 | 2 |
| 0757-0288 | R:FXD MET FLM 9.09K OHM 1% 1/8W | 28480 | 0757-0288 | 1 |
| 0757-0290 | R:FXD MET FLM 6.19K OHM 1% 1/8W | 28480 | 0757-0290 | 2 |
| 0757-0401 | R:FXD MET FLM 100 OHM 1% 1/8W | 28480 | 0757-0401 | 1 |
| 0757-0406 | R:FXD MET FLM 182 OHM 1% 1/8W | 28480 | 0757-0406 | 2 |
| 0757-0409 | R:FXD MET OX 274 OHM 1% 1/8W | 28480 | 0757-0409 | 2 |
| 0757-0413 | R:FXD MET FLM 392 OHM 1% 1/8W | 28480 | 0757-0413 | 1 |
| 0757-0414 | R:FXD FLM 432 OHM 1% 1/8W | 28480 | 0757-0414 | 1 |
| 0757-0419 | R:FXD MET FLM 681 OHM 1% 1/8W | 28480 | 0757-0419 | 1 |
| 0757-0421 | R:FXD MET FLM 825 OHM 1% 1/8W | 28480 | 0757-0421 | 3 |

**# See introduction to this section for ordering information**

Table 6-2. Replaceable Parts (Cont'd)

| hp Part No. | Description # | Mfr. | Mfr. Part No. | TQ |
|---|---|---|---|---|
| 0757-0436 | R:FXD MET FLM 4.32K OHM 1% 1/8W | 28480 | 0757-0436 | 1 |
| 0757-0438 | R:FXD MET FLM 5.11K OHM 1% 1/8W | 28480 | 0757-0438 | 2 |
| 0757-0442 | R:FXD MET FLM 10.0K OHM 1% 1/8W | 28480 | 0757-0442 | 1 |
| 0757-0444 | R:FXD MET FLM 12.1K OHM 1% 1/8W | 28480 | 0757-0444 | 2 |
| 0757-0454 | R:FXD MET FLM 33.2K OHM 1% 1/8W | 28480 | 0757-0454 | 1 |
| 0757-0489 | R:FXD MET FLM 10 OHM 1% 1/4W | 28480 | 0757-0489 | 1 |
| 0757-0725 | R:FXD MET FLM 475 OHM 1% 1/4W | 28480 | 0757-0725 | 1 |
| 0757-0726 | R:FXD MET FLM 511 OHM 1% 1/4W | 28480 | 0757-0726 | 1 |
| 0758-0002 | R:FXD MET OX FLM 560 OHM 5% 1/2W | 28480 | 0758 0002 | 1 |
| 0758-0003 | R:FXD MET OX 1000 OHM 5% 1/2W | 28480 | 0758-0003 | 7 |
| 0758-0005 | R:FXD MET OX 4700 OHM 5% 1/2W | 28480 | 0758-0005 | 1 |
| 0758-0006 | R:FXD MET OX 10K OHM 5% 1/2W | 28480 | 0758-0006 | 9 |
| 0758-0008 | R:FXD MET OX FLM 390 OHM 5% 1/2W | 28480 | 0758-0008 | 4 |
| 0758-0009 | R:FXD MET OX 6800 OHM 5% 1/2W | 28480 | 0758-0009 | 3 |
| 0758-0010 | R:FXD MET OX FLM 3300 OHM 5% 1/2W | 28480 | 0758-0010 | 1 |
| 0758-0012 | R:FXD MET OX 12K OHM 5% 1/2W | 28480 | 0758-0012 | 3 |
| 0758-0014 | R:FXD MET FLM 180 OHM 5% 1/2W | 28480 | 0758-0014 | 3 |
| 0758-0017 | R:FXD MET OX 1500 OHM 5% 1/2W | 28480 | 0758-0017 | 3 |
| 0758-0018 | R:FXD MET OX 15K OHM 5% 1/2W | 28480 | 0758-0018 | 2 |
| 0758-0019 | R:FXD MET OX 18K OHM 5% 1/2W | 28480 | 0758-0019 | 1 |
| 0758-0024 | R:FXD MET OX 100 OHM 5% 1/2W | 28480 | 0758-0024 | 3 |
| 0758-0026 | R:FXD MET OX 82 OHM 5% 1/2W | 28480 | 0758-0026 | 3 |
| 0758-0032 | R:FXD MET OX 820 OHM 5% 1/2W | 28480 | 0758-0032 | 1 |
| 0758-0033 | R:FXD MET OX 2000 OHM 5% 1/2W | 28480 | 0758-0033 | 2 |
| 0758-0036 | R:FXD MET OX 3600 OHM 5% 1/2W | 28480 | 0758-0036 | 2 |
| 0758-0039 | R:FXD MET OX 20K OHM 5% 1/2W | 28480 | 0758-0039 | 1 |
| 0758-0040 | R:FXD MET OX 47K OHM 5% 1/2W | 28480 | 0758-0040 | 2 |
| 0758-0043 | R:FXD MET OX 1800 OHM 5% 1/2W | 28480 | 0758-0043 | 3 |
| 0758-0046 | R:FXD MET OX 6200 OHM 5% 1/2W | 28480 | 0758-0046 | 2 |
| 0758-0054 | R:FXD MET OX 330 OHM 5% 1/2W | 28480 | 0758-0054 | 2 |
| 0758-0057 | R:FXD MET OX 5600 OHM 5% 1/2W | 28480 | 0758-0057 | 2 |
| 0760-0011 | R:FXD MET OX 806 OHM 1% 1W | 28480 | 0760-0011 | 2 |
| 0760-0022 | R:FXD MET FLM 330 OHM 2% 1W | 28480 | 0760-0022 | 1 |
| 1200-0087 | CLAMP:TRANSISTOR | 02735 | DF-13-A | 3 |
| 1250-0123 | CONNECTOR:RECEPTACLE | 28480 | 1250-0123 | 5 |
| 1250-0253 | CONNECTOR:RF BNC JACK | 02660 | 31-219-1021 | 2 |
| 1251-0172 | CONNECTOR:PRINTED CIRCUIT 22-CONN | 28480 | 1251-0172 | 6 |
| 1251-2357 | SOCKET:3-PIN MALE POWER RECEPTACLE | 82389 | EAC-301 | 1 |
| 1400-0042 | CLIP:CAPACITOR | 14655 | 21368-1 | 2 |
| 1400-0084 | FUSEHOLDER:EXTRACTOR POST TYPE | 79515 | 342014 | 1 |
| 1410-0052 | BUSHING:POTENTIOMETER | 28480 | 1410-0052 | 1 |
| 1450-0420 | LIGHT INDICATOR: A1C LAMP | 72765 | 599-141 WHITE | 1 |
| 1490-0030 | STAND:TILT | 28480 | 1490-0030 | 1 |
| 1520-0001 | PLATE:MOUNTING ELECTROLYTIC CAPACITOR | 28480 | 1520-0001 | 1 |
| 1850-0062 | TRANSISTOR:GERMANIUM ALLOY JUNCTION | 28480 | 1850-0062 | 8 |
| 1850-0064 | TRANSISTOR:GERMANIUM PNP 2N1183 | 86684 | 2N1183 | 3 |
| 1850-0091 | TRANSISTOR:GERMANIUM 2N2048 PNP | 87216 | 2N2048 | 4 |
| 1850-0093 | TRANSISTOR:GERMANIUM 2N1499A PNP | 87216 | 2N1499A | 8 |
| 1850-0101 | TRANSISTOR:SPL2N582 | 28480 | 1850-0101 | 2 |
| 1850-0105 | TRANSISTOR:GERMANIUM PNP SPL 2N2048 | 87216 | T-2786 | 1 |
| 1851-0023 | TRANSISTOR:GERMANIUM NPN | 28480 | 1851-0023 | 2 |
| 1853-0010 | TRANSISTOR:SILICON PNP | 28480 | 1853-0010 | 1 |

**# See introduction to this section for ordering information**

Table 6-2. Replaceable Parts (Cont'd)

| ℗ Part No. | Description # | Mfr. | Mfr. Part No. | TQ |
|---|---|---|---|---|
| 1854-0003 | TRANSISTOR:NPN SILICON | 28480 | 1854-0003 | 3 |
| 1854-0010 | TRANSISTOR:2N834 NPN SILICON | 04713 | 2N834 | 1 |
| 1854-0011 | TRANSISTOR:2N835 NPN SILICON | 04713 | 2N835 | 4 |
| 1854-0022 | TRANSISTOR:NPN SILICON | 28480 | 1854-0022 | 1 |
| 1854-0035 | TRANSISTOR:NPN SILICON | 28480 | 1854-0035 | 1 |
| 1901-0025 | DIODE:SILICON 100WV 100MA | 28480 | 1901-0025 | 2 |
| 1901-0026 | DIODE:SILICON 0.75A 200 PIV | 28480 | 1901-0026 | 6 |
| 1901-0033 | DIODE:SILICON 100MA 180WV | 28480 | 1901-0033 | 2 |
| 1901-0347 | DIODE:SILICON 8V | 28480 | 1901-0347 | 5 |
| 1901-0039 | DIODE:SILICON 200MA 50WV | 28480 | 1901-0039 | 6 |
| 1901-0040 | DIODE:SILICON 30MA 30WV | 28480 | 1901-0040 | 8 |
| 1902-0036 | DIODE BREAKDOWN:6.19V 10% | 28480 | 1902-0036 | 1 |
| 1902-0037 | DIODE BREAKDOWN:9.09V 10% | 28480 | 1902-0037 | 1 |
| 1902-0045 | DIODE BREAKDOWN:7.32V 2% | 28480 | 1902-0045 | 2 |
| 1902-0048 | DIODE BREAKDOWN:6.81V 5% | 28480 | 1902-0048 | 1 |
| 1902-0126 | DIODE BREAKDOWN:2.61V 5% | 28480 | 1902-0126 | 1 |
| 1910-0016 | DIODE:GERMANIUM 100MA AT 0.85V 60PIV | 28480 | 1910-0016 | 26 |
| 2100-0019 | R:VAR COMP 500 OHM 10% LIN 1/2W | 28480 | 2100-0019 | 1 |
| 2100-0108 | R:VAR COMP LIN 100 OHM 0% 1/3W | 28480 | 2100-0108 | 1 |
| 2100-0128 | R:VAR COMP 250 OHM 20% LIN 1/3W | 28480 | 2100-0128 | 1 |
| 2100-0350 | R:VAR COMP 1500 OHM 20% LIN 1/2W | 28480 | 2100-0350 | 1 |
| 2100-0433 | R:VAR COMP 20K OHM 10% LIN 2.25W | 28480 | 2100-0433 | 2 |
| 2100-0434 | R:VAR COMP 65K OHM 10% LIN 2.25W | 28480 | 2100-0434 | 1 |
| 2110-0201 | FUSE:CARTRIDGE 0.25 AMP SLOW BLOW | 71400 | MDL-1/4 | 1 |
| 2110-0318 | FUSE:0.125A SLOW-BLOW | 71400 | MDL 108 | 1 |
| 2370-0020 | SCREW:SST FH PHIL DR 6-32 X 3/16 | 00000 | OBD | 1 |
| 2370-0021 | SCREW:SST FH PHIL DR 6-32 X 7/16 | 00000 | OBD | 2 |
| 2515-0017 | SCREW:PAN HD PHIL DR 8-32 X 1/4 | 00000 | OBD | 1 |
| 2530-0011 | SCREW:SST FLAT HD 8-32 X 3/8 | 78189 | OBD# | 1 |
| 3101-0011 | SWITCH:SLIDE DPDT | 82389 | 11A-1013 | 1 |
| 3101-1234 | SWITCH:SLIDE DPDT | 82389 | 11A-1242A | 1 |
| 3104-0004 | SWITCH: MULTI PUSH 5 UNIT | 28480 | 3104-0004 | 5 |
| 3130-0056 | SHIELD:SWITCH 3/8"DIA CENTER HOLE | 76854 | 8565CPCD | 2 |
| 5000-0050 | TRIM:SIDES | 28480 | 5000-0050 | 1 |
| 5000-0245 | LABEL:PULSE | 28480 | 5000-0245 | 1 |
| 5000-0246 | LABEL:SQUARE WAVE | 28480 | 5000-0246 | 1 |
| 5000-0248 | LABEL:LINE | 28480 | 5000-0248 | 1 |
| 5000-0249 | LABEL:AM | 28480 | 5000-0249 | 1 |
| 5000-0731 | COVER:SIDE PERFORATED,BLUE GRAY | 28480 | 5000-0731 | 1 |
| 5000-8595 | COVER:SIDE PERFORATED,OLIVE GRAY | 28480 | 5000-8595 | 1 |
| 5040-0218 | COUPLER:SWITCH SHAFT | 28480 | 5040-0218 | 2 |
| 5060-0730 | ASSY:FRAME | 28480 | 5060-0730 | 1 |
| 5060-0740 | TOP COVER ASSY:16L FM,BLUE GRAY | 28480 | 5060-0740 | 1 |
| 5060-0752 | BOTTOM COVER ASSY:16L FM,BLUE GRAY | 28480 | 5060-0752 | 1 |
| 5060-0767 | FOOT ASSY:FM | 28480 | 5060-0767 | 1 |
| 5060-0774 | KIT:RACK MOUNT,LIGHT GRAY | 28480 | 5060-0774 | 1 |
| 5060-8589 | TOP COVER ASSY:16L FM, OLIVE GRAY | 28480 | 5060-8589 | 1 |
| 5060-8613 | BOTTOM COVER ASSY:16L FM, OLIVE GRAY | 28480 | 5060-8613 | 1 |
| 5060-8739 | KIT:RACK MOUNT, MINT GRAY (WHITE GRAY) | 28480 | 5060-8739 | 1 |
| 7122-0082 | SERIAL PLATE(115/230 VOLTS,50-400CYCLE) | 28480 | 7122-0082 | 1 |
| 8120-1348 | CABLE ASSY:POWER CORD | 70903 | KHS-7041 | 1 |
| 9100-0161 | TRANSFORMER:POWER | 28480 | 9100-0161 | 1 |
| 9100-0373 | TRANSFORMER:PULSE TURN RATIO 1:3:1 | 01961 | 4520 | 3 |
| 9100-2887 | FILTER:LINE 50/400 HZ | 05245 | F 1221A | 1 |
| 9130-0017 | TRANSFORMER:PULSE TURN RATIO 1:3:1 | 28480 | 9130-0017 | 2 |
| 9130-0019 | TRANSFORMER:PULSE 1:1 TURNS RATIO | 28480 | 9130-0019 | 1 |
| 9140-0082 | COIL:FXD RF 15 UH | 28480 | 9140-0082 | 1 |
| 9140-0115 | COIL:FXD RF 22 UH 10% | 99800 | 2150-32 | 2 |

**# See introduction to this section for ordering information**

Table 6-2. Replaceable Parts (Cont'd)

| Part No. | Description # | Mfr. | Mfr. Part No. | TQ |
|---|---|---|---|---|
| 9140-0118 | COIL:FXD 500 UH 5% | 28480 | 9140-0118 | 2 |
| 08403-005 | BRACKET:BOARD EXTENDER | 28480 | 08403-005 | 1 |
| 08403-006 | PLATE:SWITCH MOUNTING | 28480 | 08403-006 | 1 |
| 08403-008 | KNOB:RATE | 28480 | 08403-008 | 1 |
| 08403-009 | KNOB:RATE(VERNIER) | 28480 | 08403-009 | 1 |
| 08403-010 | KNOB:DELAY/WIDTH | 28480 | 08403-010 | 1 |
| 08403-011 | KNOB:DELAY/WIDTH | 28480 | 08403-011 | 2 |
| 08403-602 | CABLE ASSY:PATCH | 28480 | 08403-602 | 1 |
| 08403-603 | CABLE ASSY:SHIELDED | 28480 | 08403-603 | 1 |
| 08403-604 | BOARD ASSY:PIN DRIVER | 28480 | 08403-604 | 1 |
| 08403-60005 | BOARD ASSY:DUTY LIMIT | 28480 | 08403-60005 | 1 |
| 08403-606 | BOARD ASSY:DELAY/WIDTH | 28480 | 08403-606 | 1 |
| 08403-607 | BOARD ASSY:RATE | 28480 | 08403-607 | 1 |
| 08403-608 | BOARD ASSY:POWER SUPPLY DISTR. | 28480 | 08403-608 | 1 |
| 08403-609 | BOARD ASSY:EXTENDER | 28480 | 08403-609 | 1 |
| 08403-610 | BOARD ASSY:POWER SUPPLY | 28480 | 08403-610 | 1 |
| 08403-611 | BOARD ASSY:TRIGGER GENERATOR | 28480 | 08403-611 | 1 |
| 08403-612 | SWITCH ASSY:RATE CONTROL | 28480 | 08403-612 | 1 |
| 08403-613 | SWITCH ASSY:DELAY CONTROL | 28480 | 08403-613 | 1 |
| 08403-614 | SWITCH ASSY:WIDTH CONTROL | 28480 | 08403-614 | 1 |
| 08403-00021 | PANEL:FRONT, LIGHT GRAY | 28480 | 08403-00021 | 1 |
| 08403-00022 | PANEL:REAR | 28480 | 08403-00022 | 1 |
| 08403-00023 | PANEL:FRONT, MINT GRAY(WHITE GRAY) | 28480 | 08403-00023 | 1 |
| 08403-20001 | BUSHING:TRANSISTOR | 28480 | 08403-20001 | 6 |
| 08403-60006 | CABLE ASSY:AC | 28480 | 08403-60006 | 1 |

**# See introduction to this section for ordering information**

# TABLE 6-3.
# CODE LIST OF MANUFACTURERS

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 Handbooks.

| Code No. | Manufacturer | Address |
|---|---|---|
| 00000 | U. S. A. Common | Any supplier of U.S. |
| 00136 | McCoy Electronics | Mount Holly Springs, Pa. |
| 00213 | Sage Electronics Corp. | Rochester, N.Y. |
| 00287 | Cemco Inc. | Danielson, Conn. |
| 00334 | Humidial | Colton, Calif. |
| 00348 | Microtron Co., Inc. | Valley Stream, N.Y. |
| 00373 | Garlock Inc. | Cherry Hill, N.J. |
| 00656 | Aerovox Corp. | New Bedford, Mass. |
| 00779 | Amp. Inc. | Harrisburg, Pa. |
| 00781 | Aircraft Radio Corp. | Boonton, N.J. |
| 00815 | Northern Engineering Laboratories, Inc. | Burlington, Wis. |
| 00853 | Sangamo Electric Co., Pickens Div. | Pickens, S.C. |
| 00866 | Goe Engineering Co. | City of Industry, Cal. |
| 00891 | Carl E. Holmes Corp. | Los Angeles, Calif. |
| 00929 | Microlab Inc. | Livingston, N.J. |
| 01002 | General Electric Co., Capacitor Dept. | Hudson Falls, N.Y. |
| 01009 | Alden Products Co. | Brockton, Mass. |
| 01121 | Allen Bradley Co. | Milwaukee, Wis. |
| 01255 | Litton Industries, Inc. | Beverly Hills, Calif. |
| 01281 | TRW Semiconductors, Inc. | Lawndale, Calif. |
| 01295 | Texas Instruments, Inc., Transistor Products Div. | Dallas, Texas |
| 01349 | The Alliance Mfg. Co. | Alliance, Ohio |
| 01589 | Pacific Relays, Inc. | Van Nuys, Calif. |
| 01670 | Gudebrod Bros. Silk Co. | New York, N.Y. |
| 01930 | Amerock Corp. | Rockford, Ill. |
| 01961 | Pulse Engineering Co. | Santa Clara, Calif. |
| 02114 | Ferroxcube Corp. of America | Saugerties, N.Y. |
| 02116 | Wheelock Signals, Inc. | Long Branch, N.J. |
| 02286 | Cole Rubber and Plastics Inc. | Sunnyvale, Calif. |
| 02660 | Amphenol-Borg Electronics Corp. | Broadview, Ill. |
| 02735 | Radio Corp. of America, Semiconductor and Materials Div. | Somerville, N.J. |
| 02771 | Vocaline Co. of America, Inc. | Old Saybrook, Conn. |
| 02777 | Hopkins Engineering Co. | San Fernando, Calif. |
| 02875 | Hudson Tool & Die | Newark, N.J. |
| 03508 | G.E. Semiconductor Prod. Dept. | Syracuse, N.Y. |
| 03705 | Apex Machine & Tool Co. | Dayton, Ohio |
| 03797 | Eldema Corp. | Compton, Calif. |
| 03818 | Parker Seal Co. | Los Angeles, Calif. |
| 03877 | Transitron Electric Corp. | Wakefield, Mass. |
| 03888 | Pyrofilm Resistor Co., Inc. | Cedar Knolls, N.J. |
| 03954 | Singer Co., Diehl Div. Finderne Plant | Sumerville, N.J. |
| 04009 | Arrow, Hart and Hegeman Elect. Co. | Hartford, Conn. |
| 04013 | Taurus Corp. | Lambertville, N.J. |
| 04062 | Arco Electronic Inc. | Great Neck, N.Y. |
| 04222 | Hi-Q Division of Aerovox | Myrtle Beach, S.C. |
| 04354 | Precision Paper Tube Co. | Wheeling, Ill. |
| 04404 | Dymec Division of Hewlett-Packard Co. | Palo Alto, Calif. |
| 04651 | Sylvania Electric Products, Microwave Device Div. | Mountain View, Calif. |
| 04673 | Dakota Engr. Inc. | Culver City, Calif. |
| 04713 | Motorola, Inc., Semiconductor Prod. Div. | Phoenix, Arizona |
| 04732 | Filtron Co., Inc. Western Div. | Culver City, Calif. |
| 04773 | Automatic Electric Co. | Northlake, Ill. |
| 04796 | Sequoia Wire Co. | Redwood City, Calif. |
| 04811 | Precision Coil Spring Co. | El Monte, Calif. |
| 04870 | P.M. Motor Company | Westchester, Ill. |
| 04919 | Component Mfg. Service Co. | W. Bridgewater, Mass. |
| 05006 | Twentieth Century Plastics, Inc. | Los Angeles, Calif. |
| 05277 | Westinghouse Electric Corp. Semi-Conductor Dept. | Youngwood, Pa. |
| 05347 | Ultronix, Inc. | San Mateo, Calif. |
| 05397 | Union Carbide Corp., Elect. Div. | New York, N.Y. |
| 05574 | Viking Ind. Inc. | Canoga Park, Calif. |
| 05593 | Icore Electro-Plastics Inc. | Sunnyvale, Calif. |
| 05616 | Cosmo Plastic (c/o Electrical Spec. Co.) | Cleveland, Ohio |
| 05624 | Barber Colman Co. | Rockford, Ill. |
| 05728 | Tiffen Optical Co. | Roslyn Heights, Long Island, N.Y. |
| 05729 | Metro-Tel Corp. | Westbury, N.Y. |
| 05783 | Stewart Engineering Co. | Santa Cruz, Calif. |
| 05820 | Wakefield Engineering Inc. | Wakefield, Mass. |
| 06004 | Bassick Co., Div. of Stewart Warner Corp. | Bridgeport, Conn. |
| 06090 | Raychem Corp. | Redwood City, Calif. |
| 06175 | Bausch and Lomb Optical Co. | Rochester, N.Y. |
| 06402 | E.T.A. Products Co. of America | Chicago, Ill. |
| 06540 | Amatom Electronic Hardware Co., Inc. | New Rochelle, N.Y. |
| 06555 | Beede Electrical Instrument Co., Inc. | Penacook, N.H. |
| 06666 | General Devices Co., Inc. | Indianapolis, Ind. |
| 06751 | Components Inc., Ariz. Div. | Phoenix, Ariz. |
| 06812 | Torrington Mfg. Co., West Div. | Van Nuys, Calif. |
| 06980 | Varian Assoc. Eimac Div. | San Carlos, Calif. |
| 07088 | Kelvin Electric Co. | Van Nuys, Calif. |
| 07126 | Digitran Co. | Pasadena, Calif. |
| 07137 | Transistor Electronics Corp. | Minneapolis, Minn. |
| 07138 | Westinghouse Electric Corp. Electronic Tube Div. | Elmira, N.Y. |
| 07149 | Filmohm Corp. | New York, N.Y. |
| 07233 | Cinch-Graphik Co. | City of Industry, Calif. |
| 07256 | Silicon Transistor Corp. | Carle Place, N.Y. |
| 07261 | Avnet Corp. | Culver City, Calif. |
| 07263 | Fairchild Camera & Inst. Corp. Semiconductor Div. | Mountain View, Calif. |
| 07322 | Minnesota Rubber Co. | Minneapolis, Minn. |
| 07387 | Birtcher Corp., The | Monterey Park, Calif. |
| 07397 | Sylvania Elect. Prod. Inc., Mt. View Operations | Mountain View, Calif. |
| 07700 | Technical Wire Products Inc. | Cranford, N.J. |
| 07829 | Bodine Elect. Co. | Chicago, Ill. |
| 07910 | Continental Device Corp. | Hawthorne, Calif. |
| 07933 | Raytheon Mfg. Co., Semiconductor Div. | Mountain View, Calif. |
| 07980 | Hewlett-Packard Co., Boonton Radio Div. | Rockaway, N.J. |
| 08145 | U.S. Engineering Co. | Los Angeles, Calif. |
| 08289 | Blinn, Delbert Co. | Pomona, Calif. |
| 08358 | Burgess Battery Co. | Niagara Falls, Ontario, Canada |
| 08524 | Deutsch Fastener Corp. | Los Angeles, Calif. |
| 08664 | Bristol Co., The | Waterbury, Conn. |
| 08717 | Sloan Company | Sun Valley, Calif. |
| 08718 | ITT Cannon Electric Inc., Phoenix Div. | Phoenix, Arizona |
| 08727 | National Radio Lab. Inc. | Paramus, N.J. |
| 08792 | CBS Electronics Semiconductor Operations, Div of C.B.S. Inc. | Lowell, Mass. |
| 08806 | General Electric Co. Miniat. Lamp Dept. | Cleveland, Ohio |
| 08984 | Mel-Rain | Indianapolis, Ind. |
| 09026 | Babcock Relays Div. | Costa Mesa, Calif. |
| 09134 | Texas Capacitor Co. | Houston, Texas |
| 09145 | Tech. Ind. Inc. Atohm Elect. | Burbank, Calif. |
| 09250 | Electro Assemblies, Inc. | Chicago, Ill. |
| 09353 | C & K Components Inc. | Newton, Mass. |
| 09569 | Mallory Battery Co. of Canada, Ltd. | Toronto, Ontario, Canada |
| 09922 | Burndy Corp. | Norwalk, Conn. |
| 10214 | General Transistor Western Corp. | Los Angeles, Calif. |
| 10411 | Ti-Tal, Inc. | Berkeley, Calif. |
| 10646 | Carborundum Co. | Niagara Falls, N.Y. |
| 11236 | CTS of Berne, Inc. | Berne, Ind. |
| 11237 | Chicago Telephone of California, Inc. | So. Pasadena, Calif. |
| 11242 | Bay State Electronics Corp. | Waltham, Mass. |
| 11312 | Teledyne Inc., Microwave Div. | Palo Alto, Calif. |
| 11314 | National Seal | Downey, Calif. |
| 11453 | Precision Connector Corp. | Jamaica, N.Y. |
| 11534 | Duncan Electronics Inc. | Costa Mesa, Calif. |
| 11711 | General Instrument Corp., Semiconductor Div., Products Group | Newark, N.J. |
| 11717 | Imperial Electronic, Inc. | Buena Park, Calif. |
| 11870 | Melabs, Inc. | Palo Alto, Calif. |
| 12136 | Philadelphia Handle Co. | Camden, N.J. |
| 12361 | Grove Mfg. Co., Inc. | Shady Grove, Pa. |
| 12574 | Gulton Ind. Inc. Data System Div. | Albuquerque, N.M. |
| 12697 | Clarostat Mfg. Co. | Dover, N.H. |
| 12728 | Elmar Filter Corp. | W. Haven, Conn. |
| 12859 | Nippon Electric Co., Ltd. | Tokyo, Japan |
| 12881 | Metex Electronics Corp. | Clark, N.J. |
| 12930 | Delta Semiconductor Inc. | Newport Beach, Calif. |
| 12954 | Dickson Electronics Corp. | Scottsdale, Arizona |
| 13103 | Thermolloy | Dallas, Texas |
| 13396 | Telefunken (GmbH) | Hanover, Germany |
| 13835 | Midland-Wright Div. of Pacific Industries, Inc. | Kansas City, Kansas |
| 14099 | Sem-Tech | Newbury Park, Calif. |
| 14193 | Calif. Resistor Corp. | Santa Monica, Calif. |
| 14298 | American Components, Inc. | Conshohocken, Pa. |
| 14433 | ITT Semiconductor, A Div. of Int. Telephone & Telegraph Corp. | West Palm Beach, Fla. |
| 14493 | Hewlett-Packard Company | Loveland, Colo. |
| 14655 | Cornell Dublier Electric Corp. | Newark, N.J. |
| 14674 | Corning Glass Works | Corning, N.Y. |
| 14752 | Electro Cube Inc. | San Gabriel, Calif. |
| 14960 | Williams Mfg. Co. | San Jose, Calif. |
| 15203 | Webster Electronics Co. | New York, N.Y. |
| 15287 | Scionics Corp. | Northridge, Calif. |
| 15291 | Adjustable Bushing Co. | N. Hollywood, Calif. |
| 15558 | Micron Electronics | Garden City, Long Island, N.Y. |
| 15566 | Amprobe Inst. Corp. | Lynbrook, N.Y. |
| 15631 | Cabletronics | Costa Mesa, Calif. |
| 15772 | Twentieth Century Coil Spring Co. | Santa Clara, Calif. |
| 15801 | Fenwal Elect. Inc. | Framingham, Mass. |
| 15818 | Amelco Inc. | Mt. View, Calif. |
| 16037 | Spruce Pine Mica Co. | Spruce Pine, N.C. |
| 16179 | Omni-Spectra Inc. | Detroit, Ill. |
| 16352 | Computer Diode Corp. | Lodi, N.J. |
| 16585 | Boots Aircraft Nut Corp. | Pasadena, Calif. |
| 16688 | Ideal Prec. Meter Co., Inc. De Jur Meter Div. | Brooklyn, N.Y. |
| 16758 | Delco Radio Div. of G.M. Corp. | Kokoma, Ind. |
| 17109 | Thermonetics Inc. | Canoga Park, Calif. |
| 17474 | Tranex Company | Mountain View, Calif. |
| 17675 | Hamlin Metal Products Corp. | Akron, Ohio |
| 17745 | Angstrohm Prec. Inc. | No. Hollywood, Calif. |
| 17870 | McGraw-Edison Co. | Manchester, N.H. |
| 18042 | Power Design Pacific Inc. | Palo Alto, Calif. |
| 18083 | Clevite Corp., Semiconductor Div. | Palo Alto, Calif. |

From: FSC. Handbook Supplements
H4-1 Dated AUGUST 1966

00015-46
Revised: August, 1968

## TABLE 6-3.
## CODE LIST OF MANUFACTURERS (Cont'd)

| Code No. | Manufacturer | Address |
|---|---|---|
| 18324 | Signetics Corp. | Sunnyvale, Calif. |
| 18476 | Ty-Car Mfg. Co., Inc. | Holliston, Mass. |
| 18486 | TRW Elect. Comp. Div. | Des Plaines, Ill. |
| 18583 | Curtis Instrument, Inc. | Mt. Kisco, N.Y. |
| 18612 | Vishay Instruments Inc. | Malvern, Pa. |
| 18873 | E.I. DuPont and Co., Inc. | Wilmington, Del. |
| 18911 | Durant Mfg. Co. | Milwaukee, Wis. |
| 19315 | The Bendix Corp., Navigation & Control Div. | Teterboro, N.J. |
| 19500 | Thomas A. Edison Industries, Div. of McGraw-Edison Co. | West Orange, N.J. |
| 19589 | Concoa | Baldwin Park, Calif. |
| 19644 | LRC Electronics | Horseheads, N.Y. |
| 19701 | Electra Mfg. Co. | Independence, Kansas |
| 20183 | General Atronics Corp. | Philadelphia, Pa. |
| 21226 | Executone, Inc. | Long Island City, N.Y. |
| 21335 | Fafnir Bearing Co., The | New Britain, Conn. |
| 21520 | Fansteel Metallurgical Corp. | N. Chicago, Ill. |
| 23042 | Texscan Corp. | Indianapolis, Ind. |
| 23783 | British Radio Electronics Ltd. | Washington, D.C. |
| 24455 | G.E. Lamp Division | Nela Park, Cleveland, Ohio |
| 24655 | General Radio Co. | West Concord, Mass. |
| 24681 | Memcor Inc., Comp. Div. | Huntington, Ind. |
| 26365 | Gries Reproducer Corp. | New Rochelle, N.Y. |
| 26462 | Grobet File Co. of America, Inc. | Carlstadt, N.J. |
| 26851 | Compac/Hollister Co. | Hollister, Calif. |
| 26992 | Hamilton Watch Co. | Lancaster, Pa. |
| 28480 | Hewlett-Packard Co. | Palo Alto, Calif. |
| 28520 | Heyman Mfg. Co. | Kenilworth, N.J. |
| 30817 | Instrument Specialties Co., Inc. | Little Falls, N.J. |
| 33173 | G.E. Receiving Tube Dept. | Owensboro, Ky. |
| 35434 | Lectrohm Inc. | Chicago, Ill. |
| 36196 | Stanwyck Coil Products Ltd. | Hawkesbury, Ontario, Canada |
| 36287 | Cunningham, W.H. & Hill, Ltd. | Toronto Ontario, Canada |
| 37942 | P.R. Mallory & Co. Inc. | Indianapolis, Ind. |
| 39543 | Mechanical Industries Prod. Co. | Akron, Ohio |
| 40920 | Miniature Precision Bearings, Inc. | Keene, N.H. |
| 42190 | Muter Co. | Chicago, Ill. |
| 43990 | C.A. Norgren Co. | Englewood, Colo. |
| 44655 | Ohmite Mfg. Co. | Skokie, Ill. |
| 46384 | Penn Eng. & Mfg. Corp. | Doylestown, Pa. |
| 47904 | Polaroid Corp. | Cambridge, Mass. |
| 48620 | Precision Thermometer & Inst. Co. | Southampton, Pa. |
| 49956 | Microwave & Power Tube Div. | Waltham, Mass. |
| 52090 | Rowan Controller Co. | Westminster, Md. |
| 52983 | Sanborn Company | Waltham, Mass. |
| 54294 | Shallcross Mfg. Co. | Selma, N.C. |
| 55026 | Simpson Electric Co. | Chicago, Ill. |
| 55933 | Sonotone Corp. | Elmsford, N.Y. |
| 55938 | Raytheon Co. Commercial Apparatus & Systems Div. | So. Norwalk, Conn. |
| 56137 | Spaulding Fibre Co., Inc. | Tonawanda, N.Y. |
| 56289 | Sprague Electric Co. | North Adams, Mass. |
| 59446 | Telex Corp. | Tulsa, Okla. |
| 59730 | Thomas & Betts Co. | Elizabeth, N.J. |
| 60741 | Triplett Electrical Inst. Co. | Bluffton, Ohio |
| 61775 | Union Switch and Signal, Div. of Westinghouse Air Brake Co. | Pittsburgh, Pa. |
| 62119 | Universal Electric Co. | Owosso, Mich. |
| 63743 | Ward-Leonard Electric Co. | Mt. Vernon, N.Y. |
| 64959 | Western Electric Co., Inc. | New York, N.Y. |
| 65092 | Weston Inst. Inc. Weston-Newark | Newark, N.J. |
| 66295 | Wittek Mfg. Co. | Chicago, Ill. |
| 66346 | Minnesota Mining & Mfg. Co. Revere Mincom Div. | St. Paul, Minn. |
| 70276 | Allen Mfg. Co. | Hartford, Conn. |
| 70309 | Allied Control | New York, N.Y. |
| 70318 | Allmetal Screw Product Co., Inc. | Garden City, N.Y. |
| 70417 | Amplex, Div. of Chrysler Corp. | Detroit, Mich. |
| 70485 | Atlantic India Rubber Works, Inc. | Chicago, Ill. |
| 70563 | Amperite Co., Inc. | Union City, N.J. |
| 70674 | ADC Products Inc. | Minneapolis, Minn. |
| 70903 | Belden Mfg. Co. | Chicago, Ill. |
| 70998 | Bird Electronic Corp. | Cleveland, Ohio |
| 71002 | Birnbach Radio Co. | New York, N.Y. |
| 71034 | Bliley Electric Co., Inc. | Erie, Pa. |
| 71041 | Boston Gear Works Div. of Murray Co. of Texas | Quincy, Mass. |
| 71218 | Bud Radio, Inc. | Willoughby, Ohio |
| 71279 | Cambridge Thermionics Corp. | Cambridge, Mass. |
| 71286 | Camloc Fastener Corp. | Paramus, N.J. |
| 71313 | Cardwell Condenser Corp. | Lindenhurst L.I., N.Y. |
| 71400 | Bussmann Mfg. Div. of McGraw-Edison Co. | St. Louis, Mo. |
| 71436 | Chicago Condenser Corp. | Chicago, Ill. |
| 71447 | Calif. Spring Co., Inc. | Pico-Rivera, Calif. |
| 71450 | CTS Corp. | Elkhart, Ind. |
| 71468 | ITT Cannon Electric Inc. | Los Angeles, Calif. |
| 71471 | Cinema, Div. Aerovox Corp. | Burbank, Calif. |
| 71482 | C.P. Clare & Co. | Chicago, Ill. |
| 71590 | Centralab Div. of Globe Union Inc. | Milwaukee, Wis. |
| 71616 | Commercial Plastics Co. | Chicago, Ill. |
| 71700 | Cornish Wire Co., The | New York, N.Y. |
| 71707 | Coto Coil Co., Inc. | Providence, R.I. |
| 71744 | Chicago Miniature Lamp Works | Chicago, Ill. |
| 71785 | Cinch Mfg. Co., Howard B. Jones Div. | Chicago, Ill. |
| 71984 | Dow Corning Corp. | Midland, Mich. |
| 72136 | Electro Motive Mfg. Co., Inc. | Willimantic, Conn. |
| 72619 | Dialight Corp. | Brooklyn, N.Y. |
| 72656 | Indiana General Corp., Electronics Div. | Keasby, N.J. |
| 72699 | General Instrument Corp., Cap. Div. | Newark, N.J. |
| 72765 | Drake Mfg. Co. | Harwood Heights, Ill. |
| 72825 | Hugh H. Eby Inc. | Philadelphia, Pa. |
| 72928 | Gudeman Co. | Chicago, Ill. |
| 72962 | Elastic Stop Nut Corp. | Union, N.J. |
| 72964 | Robert M. Hadley Co. | Los Angeles, Calif. |
| 72982 | Erie Technological Products, Inc. | Erie, Pa. |
| 73061 | Hansen Mfg. Co., Inc. | Princeton, Ind. |
| 73076 | H.M. Harper Co. | Chicago, Ill. |
| 73138 | Helipot Div. of Beckman Inst., Inc. | Fullerton, Calif. |
| 73293 | Hughes Products Division of Hughes Aircraft Co. | Newport Beach, Calif. |
| 73445 | Amperex Elect Co. | Hicksville, L.I., N.Y. |
| 73506 | Bradley Semiconductor Corp. | New Haven, Conn. |
| 73559 | Carling Electric, Inc. | Hartford, Conn. |
| 73586 | Circle F Mfg. Co. | Trenton, N.J. |
| 73682 | George K. Garrett Co., Div. MSL Industries Inc. | Philadelphia, Pa. |
| 73734 | Federal Screw Products Inc. | Chicago, Ill. |
| 73743 | Fischer Special Mfg. Co. | Cincinnati, Ohio |
| 73793 | General Industries Co., The | Elyria, Ohio |
| 73846 | Goshen Stamping & Tool Co. | Goshen, Ind. |
| 73899 | JFD Electronics Corp. | Brooklyn, N.Y. |
| 73905 | Jennings Radio Mfg. Corp. | San Jose, Calif. |
| 73957 | Groov-Pin Corp. | Ridgefield, N.J. |
| 74276 | Signalite Inc. | Neptune, N.J. |
| 74455 | J.H. Winns, and Sons | Winchester, Mass. |
| 74861 | Industrial Condenser Corp. | Chicago, Ill. |
| 74868 | R.F. Products Division of Amphenol-Borg Electronics Corp. | Danbury, Conn. |
| 74970 | E.F. Johnson Co. | Waseca, Minn. |
| 75042 | International Resistance Co. | Philadelphia, Pa. |
| 75263 | Keystone Carbon Co., Inc. | St. Marys, Pa. |
| 75378 | CTS Knights Inc. | Sandwich, Ill. |
| 75382 | Kulka Electric Corporation | Mt. Vernon, N.Y. |
| 75818 | Lenz Electric Mfg. Co. | Chicago, Ill. |
| 75915 | Littlefuse, Inc. | Des Plaines, Ill. |
| 76005 | Lord Mfg. Co. | Erie, Pa. |
| 76210 | C.W. Marwedel | San Francisco, Calif. |
| 76433 | General Instrument Corp., Micamold Division | Newark, N.J. |
| 76487 | James Millen Mfg. Co., Inc. | Malden, Mass. |
| 76493 | J.W. Miller Co. | Los Angeles, Calif. |
| 76530 | Cinch-Monadnock, Div. of United Carr Fastener Corp. | San Leandro, Calif. |
| 76545 | Mueller Electric Co. | Cleveland, Ohio |
| 76703 | National Union | Newark, N.J. |
| 76854 | Oak Manufacturing Co. | Crystal Lake, Ill. |
| 77068 | The Bendix Corp., Electrodynamics Div. | N. Hollywood, Calif. |
| 77075 | Pacific Metals Co. | San Francisco, Calif. |
| 77221 | Phanostran Instrument and Electronic Co. | South Pasadena, Calif. |
| 77252 | Philadelphia Steel and Wire Corp. | Philadelphia, Pa. |
| 77342 | American Machine & Foundry Co. Potter & Brumfield Div. | Princeton, Ind. |
| 77630 | TRW Electronic Components Div. | Camden, N.J. |
| 77638 | General Instrument Corp., Rectifier Div. | Brooklyn, N.Y. |
| 77764 | Resistance Products Co. | Harrisburg, Pa. |
| 77969 | Rubbercraft Corp. of Calif. | Torrance, Calif. |
| 78189 | Shakeproof Division of Illinois Tool Works | Elgin, Ill. |
| 78277 | Sigma | So. Braintree, Mass. |
| 78283 | Signal Indicator Corp. | New York, N.Y. |
| 78290 | Struthers-Dunn Inc. | Pitman, N.J. |
| 78452 | Thompson-Bremer & Co. | Chicago, Ill. |
| 78471 | Tilley Mfg. Co. | San Francisco, Calif. |
| 78488 | Stackpole Carbon Co. | St. Marys, Pa. |
| 78493 | Standard Thomson Corp. | Waltham, Mass. |
| 78553 | Tinnerman Products, Inc. | Cleveland, Ohio |
| 78790 | Transformer Engineers | San Gabriel, Calif. |
| 78947 | Ucinite Co. | Newtonville, Mass. |
| 79136 | Waldes Kohinoor Inc. | Long Island City, N.Y. |
| 79142 | Veeder Root, Inc. | Hartford, Conn. |
| 79251 | Wenco Mfg. Co. | Chicago, Ill. |
| 79727 | Continental-Wirt Electronics Corp. | Philadelphia, Pa. |
| 79963 | Zierick Mfg. Corp. | New Rochelle, N.Y. |
| 80031 | Mepco Division of Sessions Clock Co. | Morristown, N.J. |
| 80120 | Schnitzer Alloy Products Co. | Elizabeth, N.J. |
| 80131 | Electronic Industries Association. Any brand Tube meeting EIA Standards-Washington, DC. | |
| 80207 | Unimax Switch, Div. Maxon Electronics Corp. | Wallingford, Conn. |
| 80223 | United Transformer Corp. | New York, N.Y. |
| 80248 | Oxford Electric Corp. | Chicago, Ill. |
| 80294 | Bourns Inc. | Riverside, Calif. |
| 80411 | Acro Div. of Robertshaw Controls Co. | Columbus, Ohio |
| 80486 | All Star Products Inc. | Defiance, Ohio |
| 80509 | Avery Label Co. | Monrovia, Calif. |
| 80583 | Hammarlund Co., Inc. | Mars Hill, N.C. |
| 80640 | Stevens, Arnold, Co., Inc. | Boston, Mass. |
| 80813 | Dimco Gray Co. | Dayton, Ohio |
| 81030 | International Instruments Inc. | Orange, Conn. |
| 81073 | Grayhill Co. | LaGrange, Ill. |
| 81095 | Triad Transformer Corp. | Venice, Calif. |

From: FSC. Handbook Supplements
H4-1 Dated AUGUST 1966

## TABLE 6-3.
## CODE LIST OF MANUFACTURERS (Cont'd)

| Code No. | Manufacturer | Address |
|---|---|---|
| 81312 | Winchester Elec. Div. Litton Ind., Inc. | Oakville, Conn. |
| 81349 | Military Specification | . . . . . |
| 81483 | International Rectifier Corp. | El Segundo, Calif. |
| 81541 | Airpax Electronics, Inc. | Cambridge, Maryland |
| 81860 | Barry Controls, Div. Barry Wright Corp. | Watertown, Mass. |
| 82042 | Carter Precision Electric Co. | Skokie, Ill. |
| 82047 | Sperti Faraday Inc., Copper Hewitt Electric Div. | Hoboken, N.J. |
| 82116 | Electric Regulator Corp. | Norwalk, Conn. |
| 82142 | Jeffers Electronics Division of Speer Carbon Co. | Du Bois, Pa. |
| 82170 | Fairchild Camera & Inst. Corp. Space & Defense System Div. | Paramus, N.J. |
| 82209 | Maguire Industries, Inc. | Greenwich, Conn. |
| 82219 | Sylvania Electric Prod. Inc. Electronic Tube Division | Emporium, Pa. |
| 82376 | Astron Corp. | East Newark, Harrison, N,J, |
| 82389 | Switchcraft, Inc. | Chicago, Ill. |
| 82647 | Metals & Controls Inc. Spencer Products | Attleboro, Mass. |
| 82768 | Phillips-Advance Control Co. | Joliet, Ill. |
| 82866 | Research Products Corp. | Madison, Wis. |
| 82877 | Rotron Mfg. Co., Inc. | Woodstock, N.Y. |
| 82893 | Vector Electronic Co. | Glendale, Calif. |
| 83058 | Carr Fastener Co. | Cambridge, Mass. |
| 83086 | New Hampshire Ball Bearing, Inc. | Peterborough, N.H. |
| 83125 | General Instrument Corp., Capacitor Div. | Darlington, S.C. |
| 83148 | ITT Wire and Cable Div. | Los Angeles, Calif. |
| 83186 | Victory Eng. Corp. | Springfield, N.J. |
| 83298 | Bendix Corp., Red Bank Div. | Red Bank, N.J. |
| 83315 | Hubbell Corp. | Mundelein, Ill. |
| 83324 | Rosan Inc. | Newport Beach, Calif. |
| 83330 | Smith, Herman H., Inc. | Brooklyn, N.Y. |
| 83332 | Tech Labs | Palisade's Park, N.J. |
| 83385 | Central Screw Co. | Chicago, Ill. |
| 83501 | Gavitt Wire and Cable Co. Div. of Amerace Corp. | Brookfield, Mass. |
| 83594 | Burroughs Corp. Electronic Tube Div. | Plainfield, N.J. |
| 83740 | Union Carbide Corp. Consumer Prod. Div. | New York, N.Y. |
| 83777 | Model Eng. and Mfg., Inc. | Huntington, Ind. |
| 83821 | Loyd Scruggs Co. | Festus, Mo. |
| 83942 | Aeronautical Inst. & Radio Co. | Lodi, N.J. |
| 84171 | Arco Electronics Inc. | Great Neck, N.Y. |
| 84396 | A.J. Glesener Co., Inc. | San Francisco, Calif. |
| 84411 | TRW Capacitor Div. | Ogallala, Neb. |
| 84970 | Sarkes Tarzian, Inc. | Bloomington, Ind. |
| 85454 | Boonton Molding Company | Boonton, N.J. |
| 85471 | A.B. Boyd Co. | San Francisco, Calif. |
| 85474 | R.M. Bracamonte & Co. | San Francisco, Calif. |
| 85660 | Koiled Kords, Inc. | Hamden, Conn. |
| 85911 | Seamless Rubber Co. | Chicago, Ill. |
| 86174 | Fafnir Bearing Co. | Los Angeles, Calif. |
| 86197 | Clifton Precision Products Co., Inc. | Clifton Heights, Pa. |
| 86579 | Precision Rubber Products Corp. | Dayton, Ohio |
| 86684 | Radio Corp. of America, Electronic Comp. & Devices Div. | Harrison, N.J. |
| 86928 | Seastrom Mfg. Co. | Glendale, Calif. |
| 87034 | Marco Industries | Anaheim, Calif. |
| 87216 | Philco Corporation (Lansdale Division) | Lansdale, Pa. |
| 87473 | Western Fibrous Glass Products Co. | San Francisco, Calif. |
| 87664 | Van Waters & Rogers Inc. | San Francisco, Calif. |
| 87930 | Tower Mfg. Corp. | Providence, R.I. |
| 88140 | Cutler-Hammer, Inc. | Lincoln, Ill. |
| 88220 | Gould-National Batteries, Inc. | St. Paul, Minn. |
| 88698 | General Mills, Inc. | Buffalo, N.Y. |
| 89231 | Graybar Electric Co. | Oakland, Calif. |
| 89473 | G.E. Distributing Corp. | Schenectady, N.Y. |
| 89665 | United Transformer Co. | Chicago, Ill. |
| 90030 | United Shoe Machinery Corp. | Beverly, Mass. |
| 90179 | US Rubber Co., Consumer Ind. & Plastics Prod. Div. | Passaic, N.J. |
| 90970 | Bearing Engineering Co. | San Francisco, Calif. |
| 91146 | ITT Cannon Elect, Inc., Salem Div. | Salem, Mass. |
| 91260 | Connor Spring Mfg. Co. | San Francisco, Calif. |
| 91345 | Miller Dial & Nameplate Co. | El Monte, Calif. |
| 91418 | Radio Materials Co. | Chicago, Ill. |
| 91506 | Augat Inc. | Attleboro, Mass. |
| 91637 | Dale Electronics, Inc. | Columbus, Nebr. |
| 91662 | Elco Corp. | Willow Grove, Pa. |
| 91737 | Gremar Mfg. Co., Inc. | Wakefield, Mass. |
| 91827 | K F Development Co. | Redwood City, Calif. |
| 91886 | Malco Mfg. Co., Inc. | Chicago, Ill. |
| 91929 | Honeywell Inc., Micro Switch Div. | Freeport, Ill. |
| 91961 | Nahm-Bros. Spring Co. | Oakland, Calif. |
| 92180 | Tru-Connector Corp. | Peabody, Mass. |
| 92367 | Elgeet Optical Co. Inc. | Rochester, N.Y. |
| 92607 | Tensolite Insulated Wire Co., Inc. | Tarrytown, N.Y. |
| 92702 | IMC Magnetics Corp. | Wesbury Long Island, N.Y. |
| 92966 | Hudson Lamp Co. | Kearney, N.J. |
| 93332 | Sylvania Electric Prod. Inc. Semiconductor Div. | Woburn, Mass. |
| 93369 | Robbins & Myers Inc. | Palisades Park, N.J. |
| 93410 | Stemco Controls, Div. of Essex Wire Corp. | Mansfield, Ohio |
| 93632 | Waters Mfg. Co. | Culver City, Calif. |
| 93929 | G.V. Controls | Livingston, N.J. |
| 94137 | General Cable Corp. | Bayonne, N.J. |
| 94144 | Raytheon Co., Comp. Div., Ind. Comp. Operations | Quincy, Mass. |
| 94148 | Scientific Electronics Products, Inc. | Loveland, Colo. |
| 94154 | Wagner Elect. Corp., Tung-Sol Div. | Newark, N.J. |
| 94197 | Curtiss-Wright Corp. Electronics Div. | East Paterson, N.J. |
| 94222 | South Chester Corp. | Chester, Pa. |
| 94330 | Wire Cloth Products, Inc. | Bellwood, Ill. |
| 94375 | Automatic Metal Products Co. | Brooklyn, N.Y. |
| 94682 | Worcester Pressed Aluminum Corp. | Worcester, Mass. |
| 94696 | Magnecraft Electric Co. | Chicago, Ill. |
| 95023 | George A. Philbrick Researchers, Inc. | Boston, Mass. |
| 95236 | Allies Products Corp., | Dania, Fla. |
| 95238 | Continental Connector Corp. | Woodside, N.Y. |
| 95263 | Leecraft Mfg. Co., Inc. | Long Island, N.Y. |
| 95265 | National Coil Co. | Sheridan, Wyo. |
| 95275 | Vitramon, Inc. | Bridgeport, Conn. |
| 95348 | Gordos Corp. | Bloomfield, N.J. |
| 95354 | Methode Mfg. Co. | Rolling Meadows, Ill. |
| 95566 | Arnold Engineering Co. | Marengo, Ill. |
| 95712 | Dage Electric Co., Inc. | Franklin, Ind. |
| 95984 | Siemon Mfg. Co. | Wayne, Ill. |
| 95987 | Weckesser Co. | Chicago, Ill. |
| 96067 | Microwave Assoc., West Inc. | Sunnyvale, Calif. |
| 96095 | Hi-Q Div. of Aerovox Corp. | Olean, N.Y. |
| 96256 | Thordarson-Meissner Inc. | Mt. Carmel, Ill. |
| 96296 | Solar Manufacturing Co. | Los Angeles, Calif. |
| 96306 | Microswitch, Div. of Minn.-Honeywell | Freeport, Ill. |
| 96330 | Carlton Screw Co. | Chicago, Ill. |
| 96341 | Microwave Associates, Inc. | Burlington, Mass. |
| 96501 | Excel Transformer Co. | Oakland, Calif. |
| 96733 | San Fernando Elect. Mfg. Co. | San Fernando, Calif. |
| 96881 | Thomson Ind. Inc. | Long Is., N.Y. |
| 97464 | Industrial Retaining Ring Co. | Irvington, N.J. |
| 97539 | Automatic & Precision Mfg. | Englewood, N.J. |
| 97979 | Reon Resistor Corp. | Yonkers, N.Y. |
| 97983 | Litton System Inc., Adler-Westrex Commun. Div. | New Rochelle, N.Y. |
| 98141 | R-Troncis, Inc. | Jamaica, N.Y. |
| 98159 | Rubber Teck, Inc. | Gardena, Calif. |
| 98220 | Hewlett-Packard Co., Moseley Div. | Pasadena, Calif. |
| 98278 | Microdot, Inc. | So. Pasadena, Calif. |
| 98291 | Sealectro Corp. | Mamaroneck, N.Y. |
| 98376 | Zero Mfg. Co. | Burbank, Calif. |
| 98410 | Etc Inc. | Cleveland, Ohio |
| 98731 | General Mills Inc., Electronics Div. | Minneapolis, Minn. |
| 98734 | Paeco Div. of Hewlett-Packard Co. | Palo Alto, Calif. |
| 98821 | North Hills Electronics, Inc. | Glen Cove, N.Y. |
| 98978 | International Electronic Research Corp. | Burbank, Calif. |
| 99109 | Columbia Technical Corp. | New York, N.Y. |
| 99313 | Varian Associates | Palo Alto, Calif. |
| 99378 | Atlee Corp. | Winchester, Mass. |
| 99515 | Marshall Ind., Capacitor Div. | Monrovia, Calif. |
| 99707 | Control Switch Division, Controls Co. of America | El Segundo, Calif. |
| 99800 | Delevan Electronics Corp. | East Aurora, N.Y. |
| 99848 | Wilco Corporation | Indianapolis, Ind. |
| 99928 | Branson Corp. | Whippany, N.J. |
| 99934 | Renbrandt, Inc. | Boston, Mass. |
| 99942 | Hoffman Electronics Corp. Semiconductor Div. | El Monte, Calif. |
| 99957 | Technology Instrument Corp. of Calif. | Newbury Park, Calif. |

THE FOLLOWING HP VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

| | | |
|---|---|---|
| 0000F | Malco Tool and Die | Los Angeles, Calif. |
| 0000Z | Willow Leather Products Corp. | Newark, N.J. |
| 000AB | ETA | England |
| 000BB | Precision Instrument Components Co. | Van Nuys, Calif. |
| 000CS | Hewlett-Packard Co., Colorado Springs | Colorado Springs, Colorado |
| 000MM | Rubber Eng. & Development | Hayward, Calif. |
| 000NN | A "N" D Mfg. Co. | San Jose, Calif. |
| 000QQ | Cooltron | Oakland, Calif. |
| 000WW | California Eastern Lab. | Burlington, Calif. |
| 000YY | S.K. Smith Co. | Los Angeles, Calif. |

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H4-1 Dated AUGUST 1966

00015-46
Revised: August, 1968

# APPENDIX I

BACKDATING

# MANUAL CHANGES

MODEL 8403A
MODULATOR

Make all backdating corrections in this manual according to changes below.

| SERIAL PREFIX OR NUMBER | MAKE MANUAL CHANGES |
|---|---|
| 444-<br>523- | A thru J<br>B thru J |
| 629-00650 & below<br>629-, 736-00875 & below | C thru J<br>D thru J |
| 736-01625 & below<br>736- | E thru J<br>F thru J |
| | |

| SERIAL PREFIX OR NUMBER | MAKE MANUAL CHANGES |
|---|---|
| 961-01825 & below | CHANGE G thru J |
| 961-<br>1044A 02055 & below | CHANGE H, I, J<br>CHANGE I, J |
| 1044A | CHANGE J |
| | |

CHANGE A:
(See Note 1)

Page 6-4 and 6-5, Table 6-1,

CR406 and CR413: Change from HP Stock No. 1901-0027 to 1910-0016;
Diode, Germanium: 100 Ma at 0.85 V, 60 PIV

Page 6-15, Table 6-2,

HP Stock No. 1901-0027: Change TQ from 4 to 2

HP Stock No. 1910-0016: Change TQ from 26 to 28.

NOTE 1

Diode CR406 is used with Transistor Q401 and Diode CR413 is used with Transistor Q403. If either transistor is replaced, then the diode used with it should be replaced with a diode type HP Stock No. 1901-0027 instead of the HP Stock No. 1910-0016.

CHANGE B:

Table 1-1:
Change EXTERNAL MODULATION, PULSE INPUT, repetition rate to read, "Maximum average prf, 1 MC/sec. Maximum peak prf, 2 MC/sec."

Change graph to show curved "MAXIMUM REPETITION RATE" at 500 KHz between 0.1 and 1 $\mu$s "DELAY OR WIDTH, WHICHEVER IS GREATER."

CHANGE C:

Page 5-23, Figure 5-16 and Parts List:
Change Q402 stock number from 1850-0105 to 1850-0091.

CHANGE D:

Table 6-1, 6-2:
Change T401 stock no. from 9130-0017 to 9100-0373. This is not a recommended replacement for all advanced models.

Figure 5-16 and Parts List:
Change stock number of Q407 from 1854-0003 to 1854-0010.

Change C604 from 39 pF, stock no. 0140-0190 to 200 pF, stock no. 0140-0198.

Change C605 from 47 pF, stock no. 0160-0182 to 62 pF, stock no. 0140-0205.

CHANGE E:

Parts List:
Change Q501, Q505, Q509 bushing transistor to 08403-20001
Change Q501, Q505, Q509 insulator transistor to 0340-0487

CHANGE F:

Page 2-1, Paragraph 2-7, under Power Requirements.
Delete Paragraph 2-8 and replace with the following:

2-8. The Model 8403A can be operated from either 115 or 230 volts, 50 to 100 Hz source. A slide switch (LINE VOLTAGE, S1) located on rear panel, converts the instrument for operation from 115 to 230 volts. A 1/4-ampere slow-blow fuse is used for both 115-volt and 230-volt operation.

Page 4-7, Paragraph 4-38, Duty Limit Indicator Circuit.
Replace Paragraphs 4-39 and 4-40 with the following:

4-39. The duty limit circuit is shown in Figure 14. The maximum duty cycle of the instrument is dependent on pulse-rate, delay, and width control settings. To insure that control settings do not result in a pulse which exceeds the duty cycle limit, a duty-limit circuit is provided for internal pulse mode only. If duty limit is exceeded the Duty Limit lamp will flash.

4-40. The circuit is supplied from primary power through INTERNAL pulse switch S3, half-wave rectifier (CR601), relaxation oscillator (R601-604, C601-6-3), and rate, delay, and width multiplier switches. When rate multiplier is in X1000 position and delay an and/or width multipliers are in X10 positions, the relaxation oscillator drives Duty Limit lamp. This lamp is a neon lamp and some lamps will remain lit and not flash at high-line primary power (127 VAC - 115 VAC operation of 253 VAC - 230 VAC operation). For this reason resistor R602 is a selected value and will normally be either 681K ohm or any value between 900K ohm and 1 Megohm.

CHANGE F: (cont'd) Page 4-9, Figure 4-14:
Change figure to new figure.

Page 5-13, Figure 5-5:
Change to new figure.

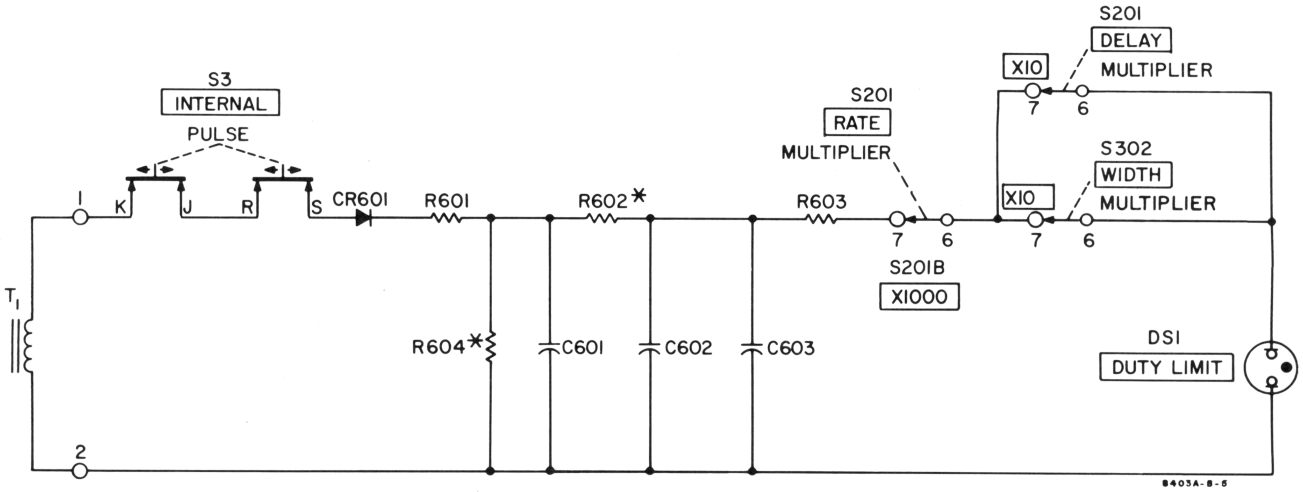



Figure 4-14. Duty Limit Circuit
(Part of Change F)

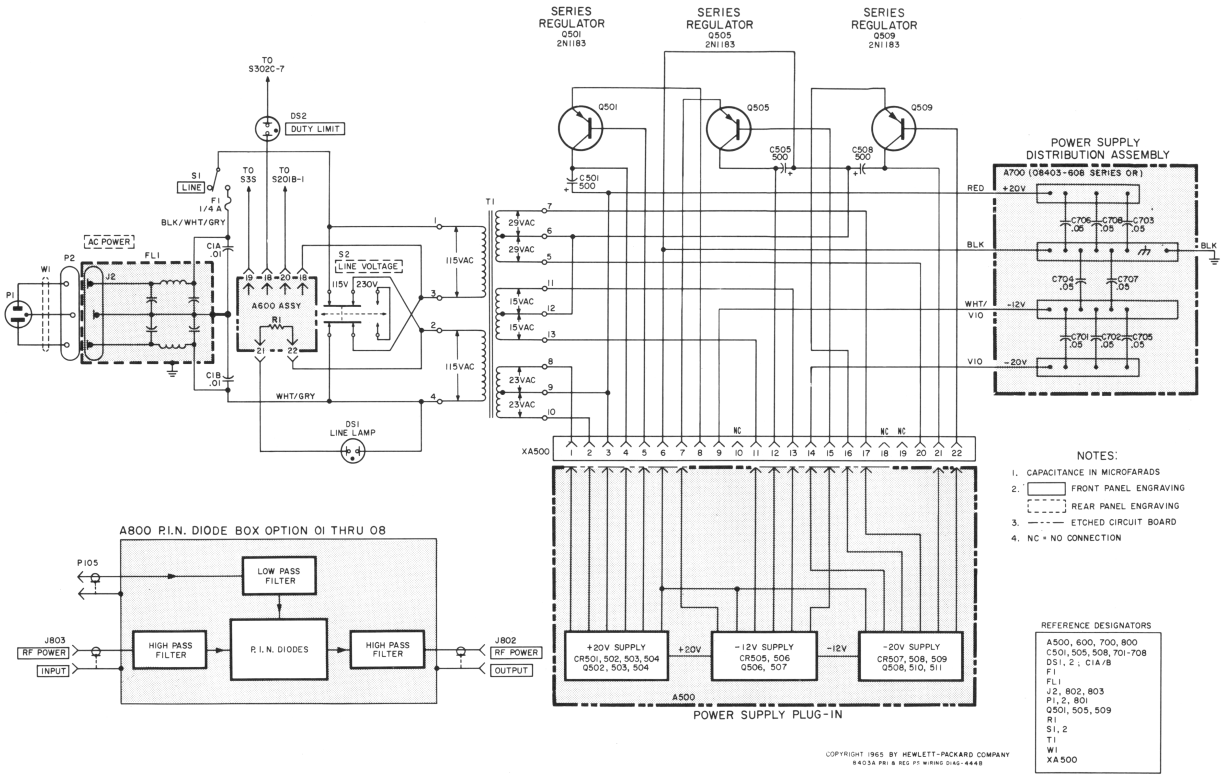
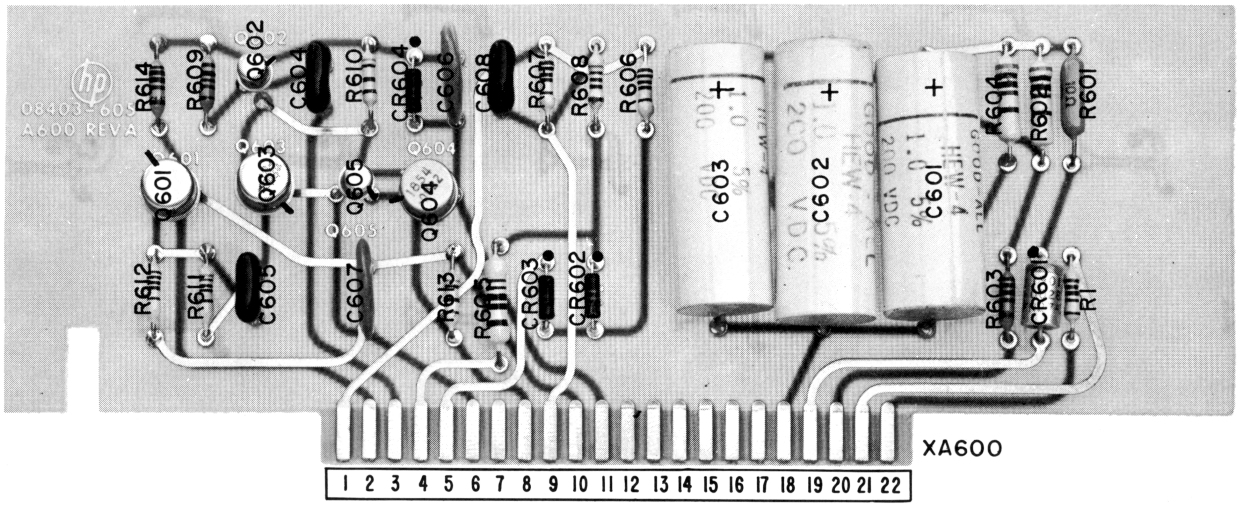


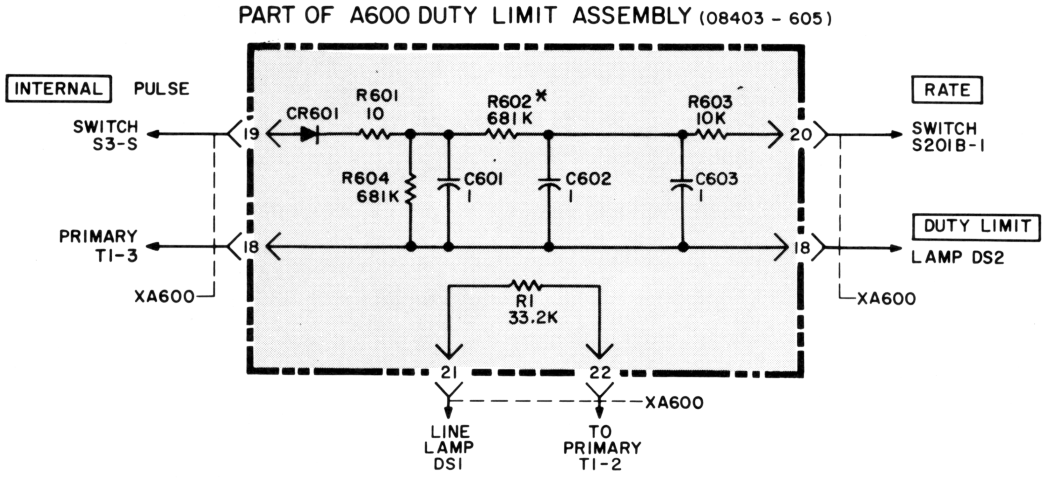

*Figure 5-5. Power Supply Wiring Diagram*

CHANGE F: (cont'd) Page 5-22, Figure 5-15:
Add pictorial shown below:




(Part of Change F)

Page 5-15, Figure 5-18:
Add schematic describing "Part of A600 Duty Limit Assembly (08403-605).



Parts List:
Change: A600 Board Assembly: Duty Limit to HP No. 08403-605.
Add: C601, C602, and C603, HP No. 0170-0018 C:FXD MY 1μf. 5% 200 WVDC.
Add: CR601, HP No. 1901-0028, Diode, Silicon 0.75A 400 PIV.
Change: DS2 to HP No. 1450-0048.
Change: F1 (115V) to HP No. 2110-0018.
Change: FL1 to HP No. 9110-0086.
Change: J2 to, "Part of FL1 NSR".
Delete: R2
Add: R601, HP No. 0757-0489, R:fxd MET FLM 10 ohm 1% 1/4W.
R602, HP No. 0757-0792, R:fxd MET FLM 681K ohm 1% 1/4W, factory selected.
R603, HP No. 0757-0442, R:fxd MET FLM 10.0K ohm 1% 1/8W.
R604, HP No. 0757-0792, R:fxd MET FLM 681K ohm 1% 1/4 W.
Change: S2 to HP No. 3101-0033.
Change: W1 to HP No. 8120-0078.
Change: Front panel to HP No. 08403-001.
Change: Rear panel to HP No. 08403-002.
Delete: Cable Assy, AC, HP No. 08403-60006.

CHANGE G: Change DS1 to HP No. 1450-0048.

CHANGE H: Change DS1 from HP No. 1450-0420 to HP No. 1450-0419.

CHANGE I: Page 5-23, Figure 5-16 and Parts List
Change C605 to 47pF HP Part No. 0160-0182

CHANGE J: Parts List: (Page 6-12, 6-16)
Delete: 08403-00023 Panel Front, 1 per
Delete: 5060-8589 Cover Assy Top 16L, 1 per
Delete: 5060-8613 Cover Assy Bottom 16L, 1 per
Delete: 5060-8739 Rack Mt Kit, 1 per
Delete: 0370-1400 Pushbutton, 4 per
Delete: 0370-1877 Knob-PB, 1 per
Delete: 5000-8595 Cover Side
Delete: 5000-8595 Cover Side 3X16, 2 per

# APPENDIX II - OPTIONS 001—009[1]

The 8403A-Option 001 through 008 instruments consist of a PIN Modulator mounted internally with the type N RF input and output connectors of the PIN Modulator protruding from the front panel in place of PULSE OUTPUTS connectors. The specially shaped output connector is removed from the instrument and the BIAS connector of the PIN Modulator is connected directly to the J105 internally. The general purpose output cable and connector assembly is mounted on the instrument rear panel.

## SPECIFICATIONS

The specifications for the Model 8403A-Option 001 through 008 are the same as those of the standard Model 8403A except for the addition of RF. RF INPUT and OUTPUT CHARACTERISTICS (applied to RF input and output connectors of PIN MODULATOR protruding from front panel). Option 009 provides for the Sync output and external modulation input connectors to be located on the rear panel and for the pulse output (or RF input and output) connectors to also be located on the rear panel only. Additional specifications are listed in Table 1.

Table 1. Rf Input/Output Specifications for Model 8403A - Option

| | 001 | 002 | 003 | 004 | 005 | 006 | 007 | 008 |
|---|---|---|---|---|---|---|---|---|
| Frequency Range (GHz) | 0.8-2.4 | 0.8-2.4 | 1.8-4.5 | 1.8-4.5 | 3.7-8.3 | 3.7-8.3 | 7.0-12.4 | 7.0-12.4 |
| Dynamic Range (dB) | 35 | 80 | 35 | 80 | 35 | 80 | 35 | 80 |
| Min Insertion Loss (dB)[1] | < 2.0 | < 2.0 | < 2.5 | < 3.5[2] | 2.5 | < 3.5 | < 4.5 | < 5.5 |
| Typical Rise Time (nsec)[3] | 40 | 30 | 40 | 30 | 30 | 30 | 30 | 30 |
| Typical Decay Time (nsec)[3] | 30 | 20 | 30 | 20 | 20 | 20 | 20 | 20 |
| SWR, Min Attenuation | 1.5 | 1.6 | 1.5 | 1.6[4] | 1.8 | 2.0 | 1.8 | 2.0 |
| SWR, Max Attenuation | 1.8 | 2.0 | 1.8 | 2.0 | 2.0 | 2.2 | 2.0 | 2.2 |
| Maximum Input Power, Peak or CW (watts) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

1. +5 v bias
2. 4.0, 4.0 to 4.5 GHz
3. Driven by HP 8403A Modulator
4. 2.0, 4.0 to 4.5 GHz

A list of component parts and the PIN Modulator which is included with/or may be ordered for each 8403A-Option is given in Table 2. Details of mounting location, replaceable parts identification, and electrical adjustment of 8403A for use with internally mounted PIN Modulator are included in this appendix. Also, a discussion of operation, usage, and principles of operation for the PIN Modulators is included in the Operating Note (8730A/B-series), a copy of which has been printed into this appendix. Note: additional copies of this Operating Note can be obtained from your local Hewlett-Packard field office upon request.

## INSTALLATION PROCEDURE.

1. TOOLS REQUIRED.
   a. Screwdriver
   b. Gas pliers with nylon teeth
2. 8403A PREPARATION
   a. Remove 8403A top and bottom covers and disconnect BNC-to-BNC cable assembly connected between J105 and J107 (Refer to Figure 1).
   b. Disconnect cable connection to J106.
   c. Disconnect both front panel BNC-to-BNC connector adapters (J106 and J107) from instrument.

[1] Formerly Options 01-09.

d. Remove one of the rear panel plug-buttons from 8403A and attach one of the BNC-to-BNC connector adapters (J106 or J107) in hole at rear panel.

e. Pull BNC cable removed from J106 through instrument deck hole indicated in Figure 1 and connect to newly installed rear panel connector (this connector is now the General Pulse Output J106).

3. OPTION INSTALLATION.

a. Refer to Figure 2 and remove spacer and lock nut from both PIN Modulator type N connectors.

b. For installation of 8403A Options 002 and 004, refer to Figure 3 for the following procedure. For installation of all other 8403A options, refer to Figure 4.

c. Attach rigid cable assembly to PIN Modulator as illustrated in Figure 4 (Note: for 8403A Options 002 and 004, the rigid cable assembly is not shown because it is not used).

NOTE

Before installation of PIN Modulator in 8403A, note current value stamped on label attached to underside of PIN Modulator. This value should be recorded since it will be needed for instrument adjustment prior to usage.

d. Place PIN Modulator in 8403A as illustrated.

e. Holding PIN Modulator in place, place 8403A on one side and attach mounting hardware to PIN Modulator through 8403A deck.

f. Place 8403A back on bottom and attach one lock nut to each type N connector protruding through 8403A front panel.

g. Be sure that both lock nuts and the two retaining screws are tightly attached.

h. Using the cable removed from J105 in the 8403A PREPARATION procedure above, connect J105 to PIN Modulator BIAS connector.

4. ELECTRICAL ADJUSTMENT.

a. Before instrument can be used, the ON/OFF ADJ adjustment procedure must be performed. For ON/OFF adjustment procedure, refer to Page 3-1 of this manual.

b. To perform adjustment procedure, remove cable connecting J105 to PIN Modulator BIAS connector. After adjustment, replace cable connection and replace 8403A top and bottom covers.

Table II-2. Parts Supplied for 8403A - Option Mounting

| Option | PIN Modulator | Rigid Cable Assembly | Mounting Hardware (Req'd number - 2 ea.) |
|---|---|---|---|
| 001 | 8731A | 08731-601 | Machine screw, 6-32 x 3/8" (hp Stock No. 2390-0008) |
| 002 | 8731B | not any | |
| 003 | 8732A | 08731-601 | |
| 004 | 8732B | not any | Flat washer, #6 x 0.3125" O.D. (hp Stock No. 3050-0010) |
| 005 | 8733A | 08733-601 | |
| 006 | 8733B | 08733-602 | |
| 007 | 8734A | 08733-601 | Lock washer, spring, #6 (hp Stock No. 2190-0018) |
| 008 | 8734B | 08733-602 | |

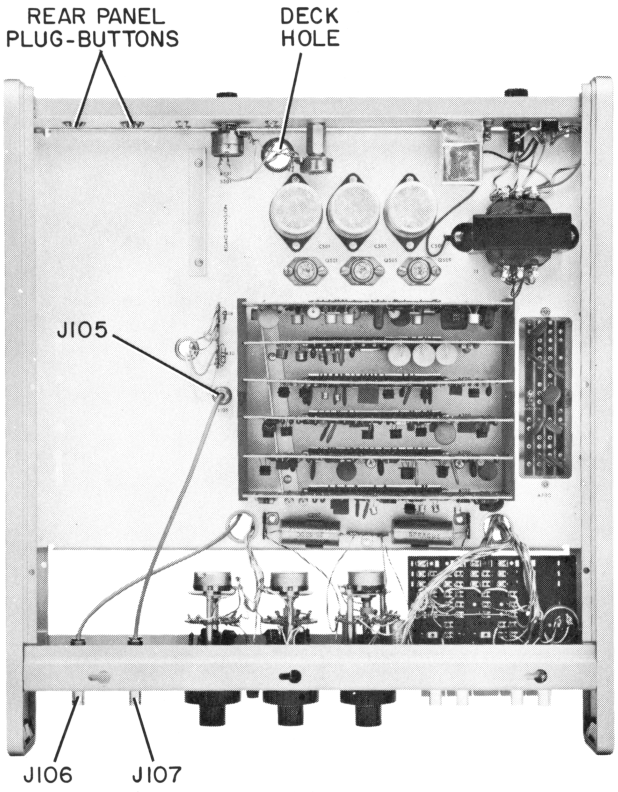



Figure 1. Model 8403A Bottom View
(No installed Options)

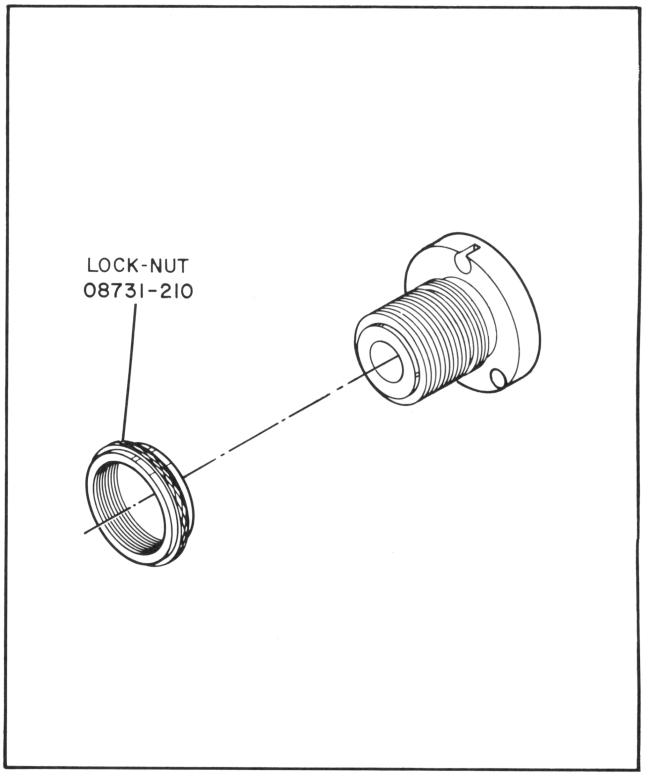



Figure 2. PIN Modulator Type N Connector

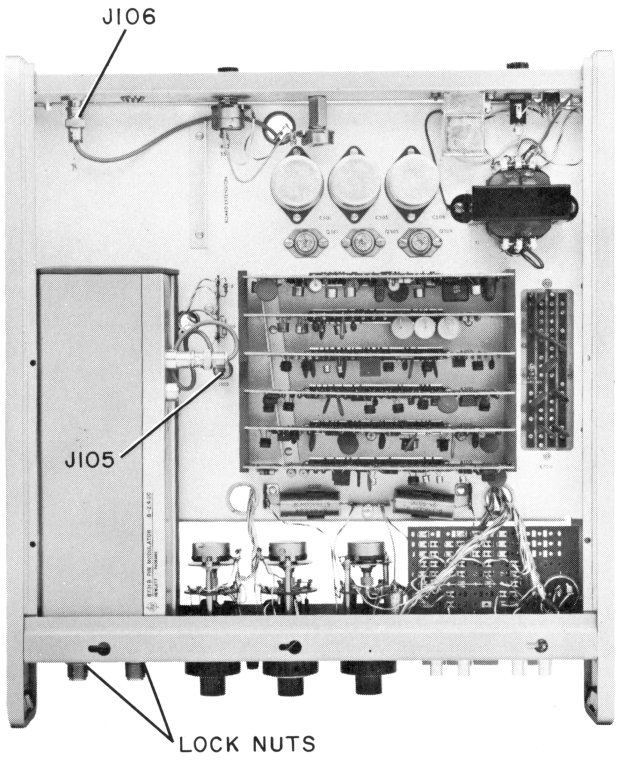



Figure 3. Model 8403A with Option 002 Installed
(Option 004 is identical physically)

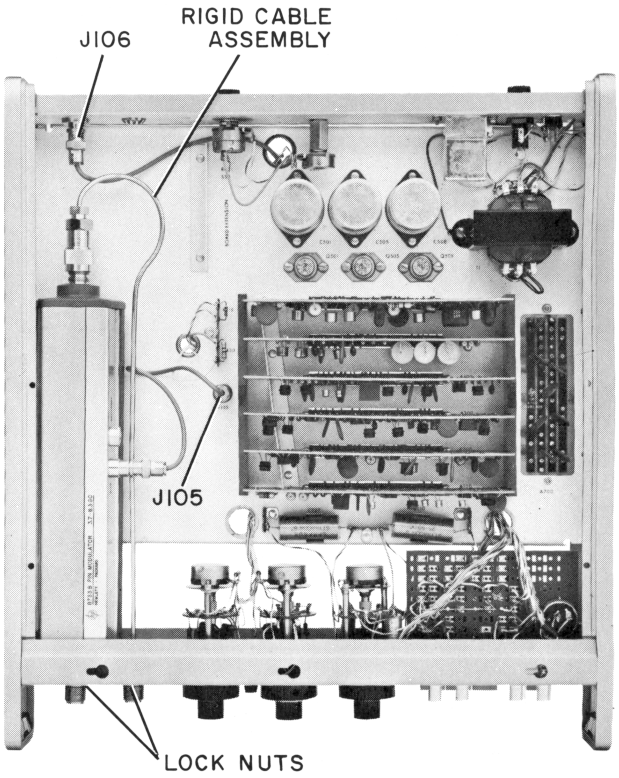



Figure 4. Model 8403A with Option 006 Installed
(Options 001, 003, 005, 007, 008 are nearly identical)

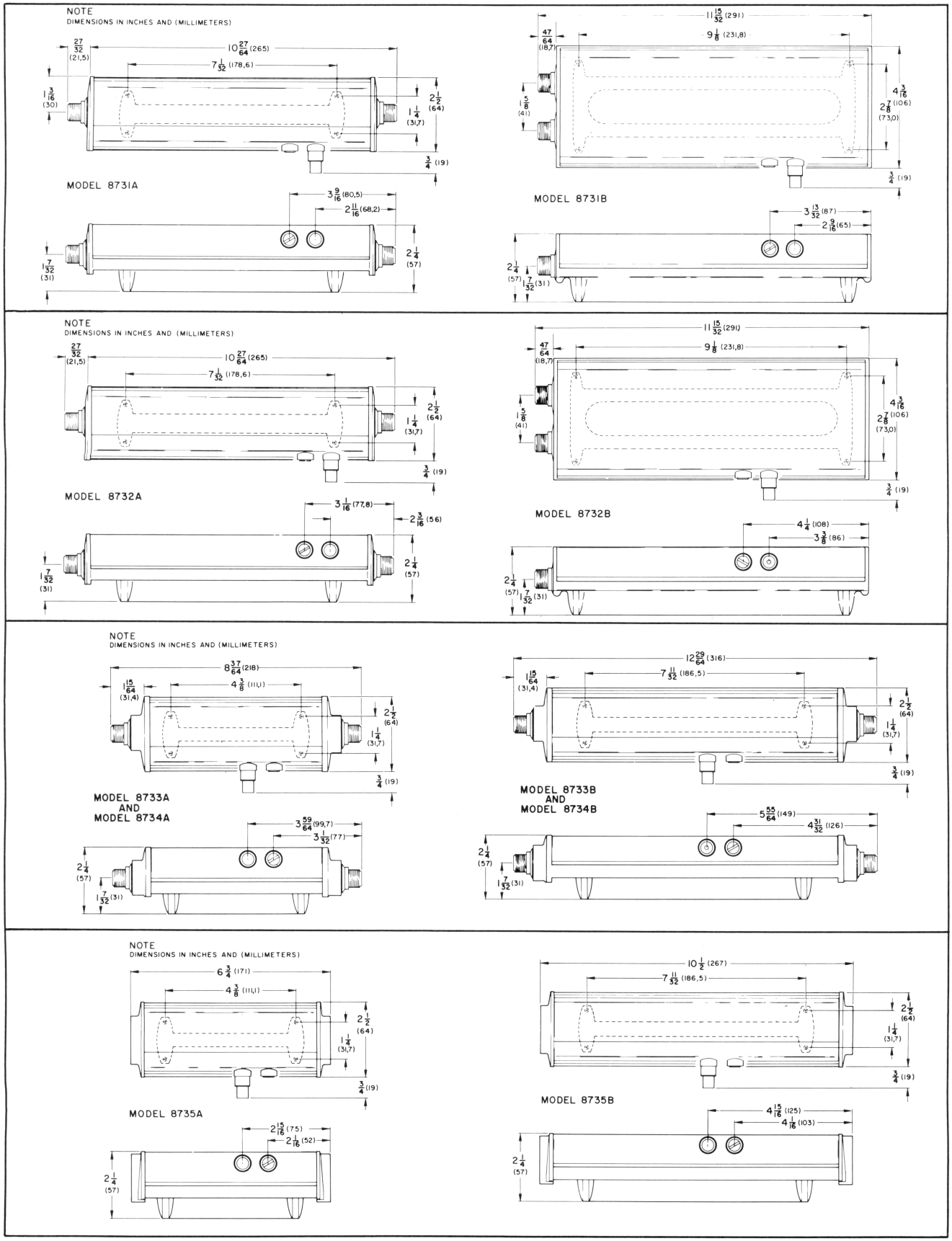



Figure 2. General Outside Dimensions

# APPENDIX II

# PIN MODULATORS series 8730A/B

OPERATING NOTE 1 APR 65

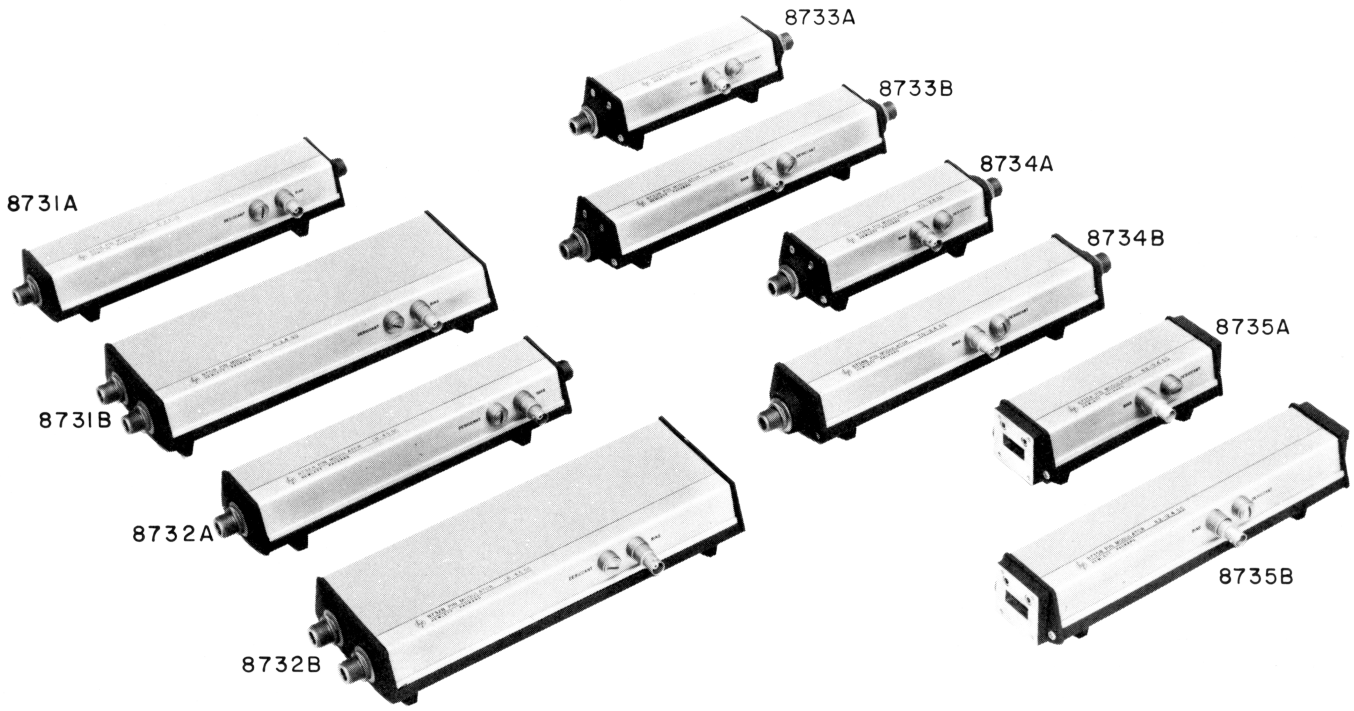



Figure 1. Model 8730 Series PIN Modulators

## 1. INTRODUCTION.

2. The Hewlett-Packard 8730 series of PIN modulators (Figure 1) are variable RF attenuators whose input and output impedance is nearly constant for all levels of attenuation. The 8730 PIN Modulators cover the coaxial range from 0.8 to 12.4 GHz in four overlapping bands in addition to X-band in waveguide. Two models are available in each band: an "A" model which provides at least 35 dB of attenuation range, and a "B" model which provides at least 80 dB. Typical uses include pulsing, switching, leveling, and amplitude modulating of RF signals. Table 1 lists complete PIN Modulator specifications.

## 3. PRECAUTIONS.

4. MAXIMUM RF POWER. The maximum input rating (peak or CW) for the PIN Modulators is 1 watt. Excessive RF power levels will cause internal damage.

5. MAXIMUM BIAS INPUT. DC voltage applied to the BIAS input must not exceed +20 volts or -10 volts. Excessive DC voltages may cause internal damage

## 6. STORAGE AND SHIPMENT.

7. ENVIRONMENT. Temperature during storage or shipment should be limited as follows:

a. Maximum temperature: 149°F (+65°C).

b. Minimum temperature: -40°F (-40°C).

c. Humidity Maximum: 95%.

8. PACKAGING. To protect the 8730 PIN Modulators during storage or shipment, always use the best packaging methods available. The following suggested steps can be used as a guide for packaging.

a. The original carton, if undamaged, can be reused.

b. If the original carton is not usable, a double-walled carton (200 lb/sq inch bursting test) should be used.

c. Wrap instrument in heavy protective paper to avoid abrasion.

d. Place in carton, surrounded by at least four inches of tightly packed shock absorbing material.

e. Seal carton with strong tape or metal bands.

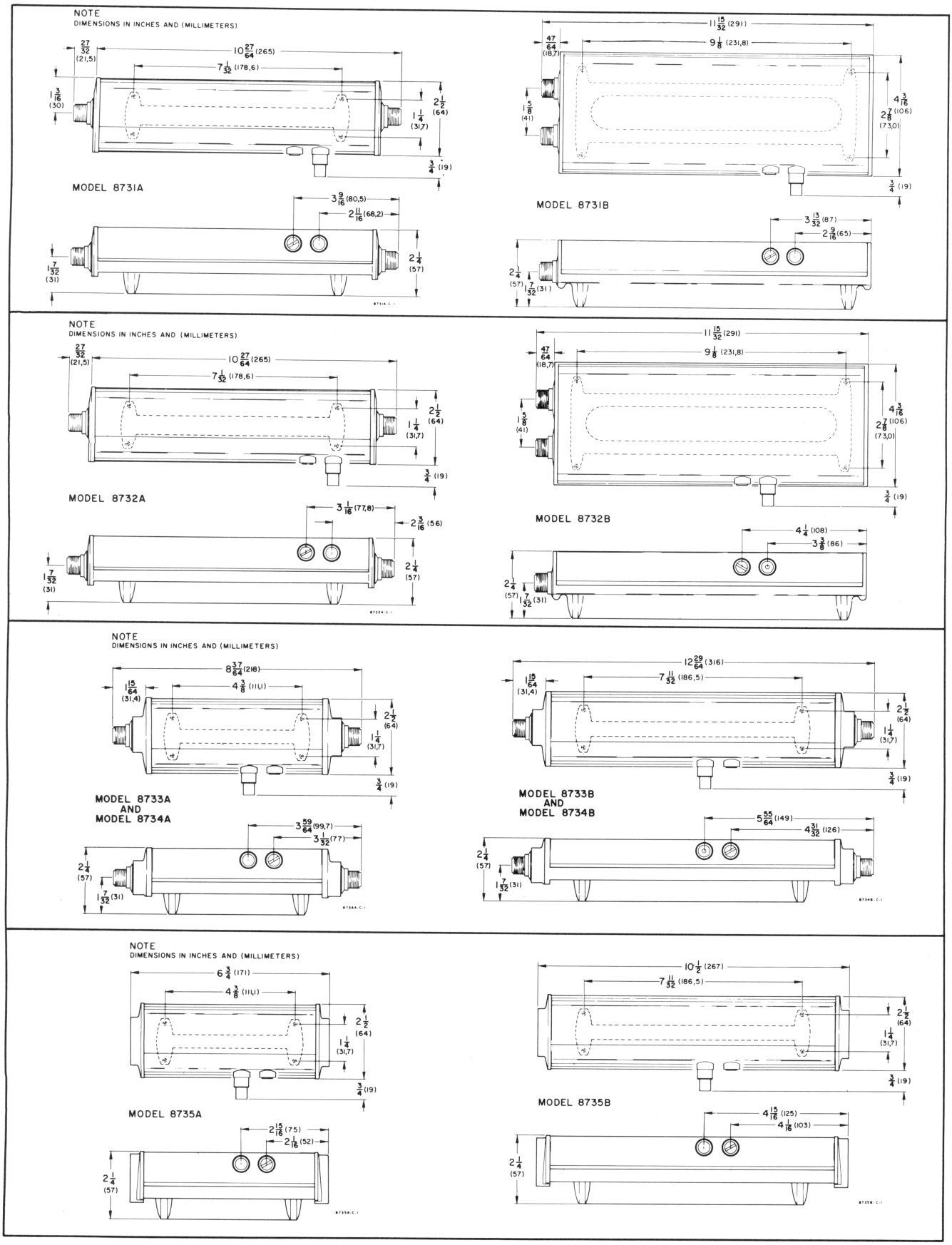



Figure 2. General Outside Dimensions

Table 1. Specifications

| | 8731A | 8731B | 8732A | 8732B | 8733A | 8733B | 8734A | 8734B | 8735A | 8735B |
|---|---|---|---|---|---|---|---|---|---|---|
| Frequency Range (gc) | 0.8-2.4 | 0.8-2.4 | 1.8-4.5 | 1.8-4.5 | 3.7-8.3 | 3.7-8.3 | 7.0-12.4 | 7.0-12.4 | 8.2-12.4 | 8.2-12.4 |
| Dynamic Range (db) | 35 | 80 | 35 | 80 | 35 | 80 | 35 | 80 | 35 | 80 |
| Min. Insertion Loss (db)[1] | < 1.5 | < 2.0 | < 2.0 | < 3.5[2] | 2.0 | < 3.0 | < 4.0 | < 5.0 | < 4.0 | < 5.0 |
| Typical Rise Time (nsec)[3] | 40 | 30 | 40 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Typical Decay Time (nec)[3] | 30 | 20 | 30 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| SWR, Minimum Attenuation | 1.5 | 1.6 | 1.5 | 1.6[4] | 1.8 | 2.0 | 1.8 | 2.0 | 1.7 | 1.9 |
| SWR, Maximum Attenuation | 1.8 | 2.0 | 1.8[9] | 2.0 | 2.0 | 2.2 | 2.0 | 2.2 | 2.0 | 2.2 |
| Maximum Input Power, Peak or CW (watts) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Bias Limits (volts)[5] | +20, -10 | +20, -10 | +20-10 | +20, -10 | +20, -10 | +20, -10 | +20, -10 | +20, -10 | +20, -10 | +20, -10 |
| Typical Forward Bias Input Resistance (ohms)[6] | 300 | 100 | 300 | 100 | 300 | 100 | 300 | 100 | 300 | 100 |
| RF Connector Type | N[8] | N[8] | N[8] | N[8] | N[8] | N[8] | N[8] | N[8] | W/G[7] | W/G[7] |
| Weight (lbs) | 2-3/4 | 5-1/2 | 2-3/4 | 5-1/2 | 2 | 3 | 2 | 3 | 2 | 3 |
| (kg) | 1,2 | 2,5 | 1,2 | 2,5 | 0,9 | 1,4 | 0,9 | 1,4 | 0,9 | 1,4 |
| Dimensions | Illustrated in Figure 2 | | | | | | | | | |

1. +5 bias
2. 4.0, 4.0 to 4.5 GHz
3. Driven by HP 8403A Modulator
4. 2.0, 4.0 to 4.5 GHz
5. Negative voltage applies forward bias to diodes
6. At attenuation levels of 10 dB or more
7. Fits 1 x 1/2 in. (WR 90) waveguide
8. Standard female type N
9. 1.8, 1.8 to 4.0 GHz; 2.0, 4.0 to 4.5 GHz.

## 9. PERMANENT MOUNTING.

10. Four 6-32 tapped mounting holes have been provided for mounting purposes. The location of these holes and the overall external dimensions of the PIN Modulators are illustrated in Figure 2.

**CAUTION**

Also on the PIN Modulator underside are the four cover retaining screws and the PIN diode retaining screws. Any movement or adjustment of diode retaining screws will cause permanant damage.

## 11. PRINCIPLES OF OPERATION.

12. The PIN Modulator is a high-speed, current-controlled absorption type attenuator. A simplified illustration of the modulator is shown in Figure 3. Each PIN unit includes a low-pass filter, two high-pass filters, a number of PIN diodes, and a 50-ohm strip transmission line (ridged waveguide in the higher frequency Model 8733, 8734, and 8735 units).

13. The PIN diode is a silicon junction diode whose P and N trace regions are separated by a layer of intrinsic (I) semiconductor (silicon). Thus the name PIN diode. At frequencies below about 100 MHz the PIN diode rectifies as a junction diode. However, at frequencies above 100 MHz, rectification ceases due to stored charge in the intrinsic (I) layer and the diode acts like a resistance by conducting current in both directions. This equivalent resistance is inversely proportional to the amount of charge in the I layer. An increase in forward bias current (current at a negative voltage) increases the stored charge and decreases the equivalent resistance of the PIN diodes. When reverse bias is applied, reverse current flows until stored charge is depleted at which time equivalent resistance becomes a maximum in the order of thousands of ohms.

14. PIN DIODES IN SHUNT. To understand how a PIN Modulator works, consider the following: the PIN diodes are mounted as shunt elements between the RF transmission path and ground. The transmission path has a characteristic impedance of 50 ohms. When the PIN diodes are forward-biased the equivalent diode resistance is about 30 ohms and most of the RF energy is absorbed by the diodes instead of propagating down the 50-ohm transmission path. However, when the diodes are reverse- or back-biased the equivalent diode resistance is in the order of thousands of ohms and the microwave currents will flow down the transmission path because diode resistance compared to the 50-ohm path impedance is negligible.

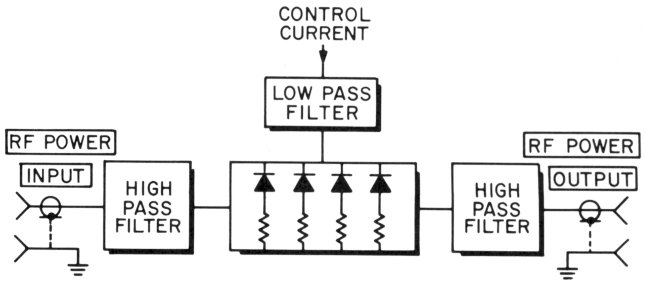



Figure 3. Simplified Block Diagram of PIN Modulator

15. BIASING.

16. Each individual PIN Modulator has a label attached to the underside of its casting body. This label has a DC bias current value stamped onto it. This stamped current is the forward-bias current required to produce rated RF attenuation across the frequency band. For "A" models, the bias current for at least 35 db is typically 3-1/2 to 5 milliamperes (about -0.7 volts DC at the BIAS input). For "B" models, the bias current

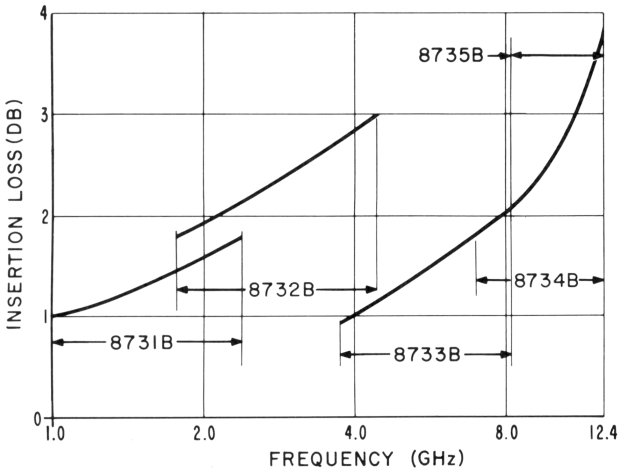



Figure 4. Typical Insertion Loss Curves

for at least 80 dB is typically 6 to 7 milliamperes (about -0.7 volts DC at the BIAS input). For applications where a minimum insertion loss is important, a back-bias of about +5 to 7 volts DC should be applied to the BIAS input. Back-biasing can result in as much a 1 dB improvement in insertion loss over zero bias. A typical plot of the maximum values of minimum insertion loss is shown in Figure 4. Note: A typical plot for the "A" models would be the same except that maximum losses are less.

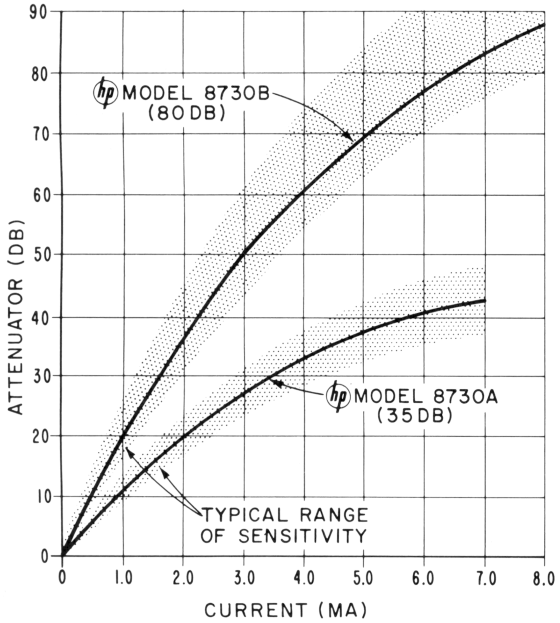



Figure 5. Typical Sensitivity
(Plotted with frequency constant)

17. The attenuation increases with forward bias current almost linearly in dB until diode saturation occurs. The attenuation sensitivity varies from unit to unit but the sensitivity of a given unit is predictable. Therefore, intermediate values of attenuation can be derived once the current values for a low and high attenuation are established. The range of expected sensitivities is shown as the shaded areas in the plots of typical 35-dB and 80-dB attenuation characteristics in Figure 5.

18. The attenuation with a constant forward-bias varies with frequency. This variation is small at low levels of attenuation and more noticeable at higher values of attenuation (see Figure 6). In addition, it should be noted that attenuation is a minimum at each end of the frequency band. Thus, the frequency band can be exceeded provided a degradation in attenuation range as well as other specifications is acceptable. Note: exceeding the band limits by a large degree is unpractical.

19. IMPEDANCE MATCH.

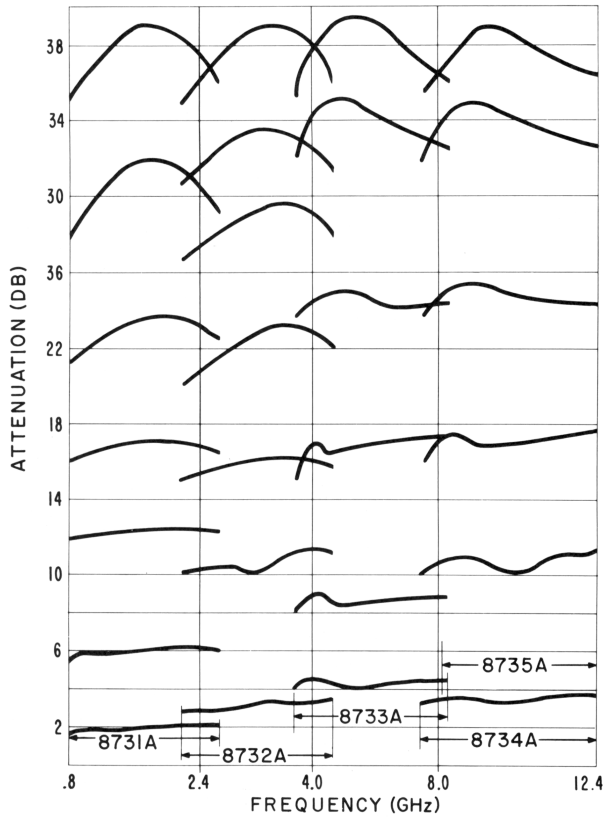
20. The PIN Modulator has a good impedance match at all levels of attenuation over its frequency range. This match is illustrated in Figure 7 which shows the SWR of a typical PIN Modulator measured under both zero bias and maximum forward bias conditions. Hence, with this constant match, frequency pulling effects due to the PIN Modulator is negligible. If the PIN Modulator is used outside specified frequency range, SWR characteristics will be degraded in addition to other operating specifications. However, spurious responses can result when exceeding specified frequency range. Note: exceeding band limits by a large degree is not generally practical.

21. TEMPERATURE STABILITY.

22. The attenuation variation with applied bias current and bias voltage at different temperatures is illustrated, over a limited range, in Figure 8. Attenuation in DB varies almost linearly with current, while variation with voltage follows an almost perfect exponential curve. If a constant voltage is maintained, the attenuation rises with increasing temperature. With a constant current, the attenuation drops with increasing temperature. The fact that the attenuation varies oppositely with temperature for constant-voltage and constant-current operation suggests that an optimum voltage with a selected series resistor added between the source and the PIN Modulator would give temperature compensation over a limited operating range. This compensation is not built into the PIN Modulator.

## 23. GENERAL OPERATION.

24. The PIN Modulators are three-port devices which accept RF power at either end-port and depending upon the BIAS signal applied, provide a modulated RF output at the other end-port. As an operating device, the PIN Modulator should be thought of as a variable RF attenuator whose attenuation level is controlled by DC current and voltage. By applying a +5 volt DC potential to the BIAS input connector, RF signals will be passed through the PIN Modulator with only minimum insertion loss. By applying a current equal to the value stamped on the instrument label (at about 0.7



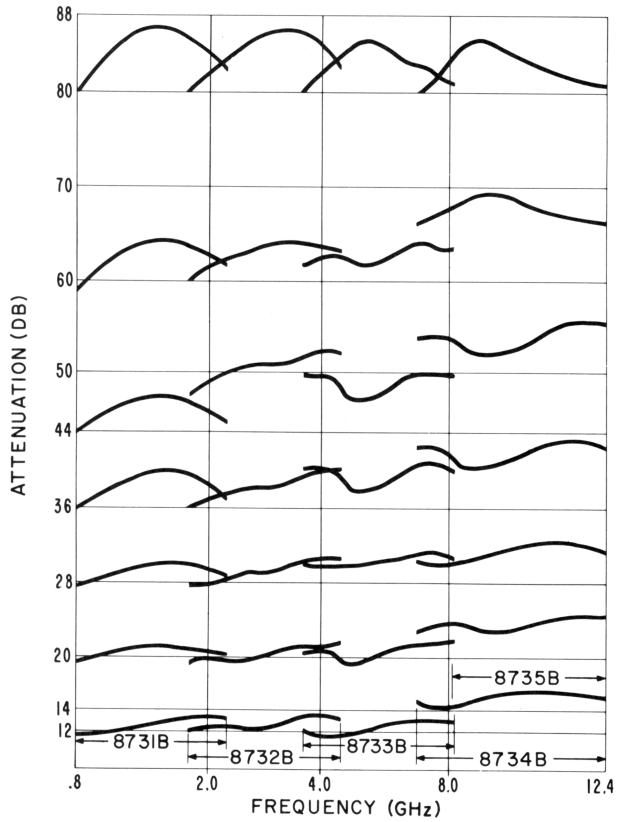




Figure 6. Typical Frequency Response

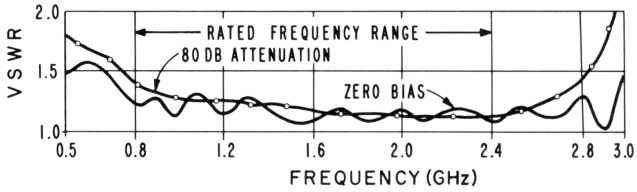
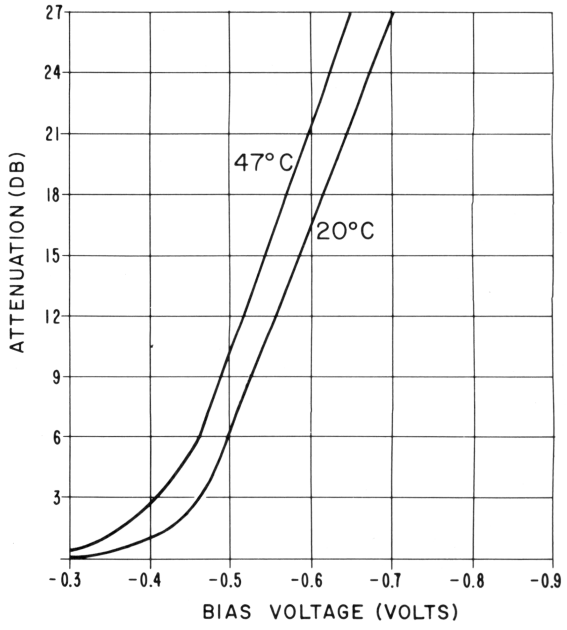



Figure 7. Typical SWR of a PIN Modulator (8732B)



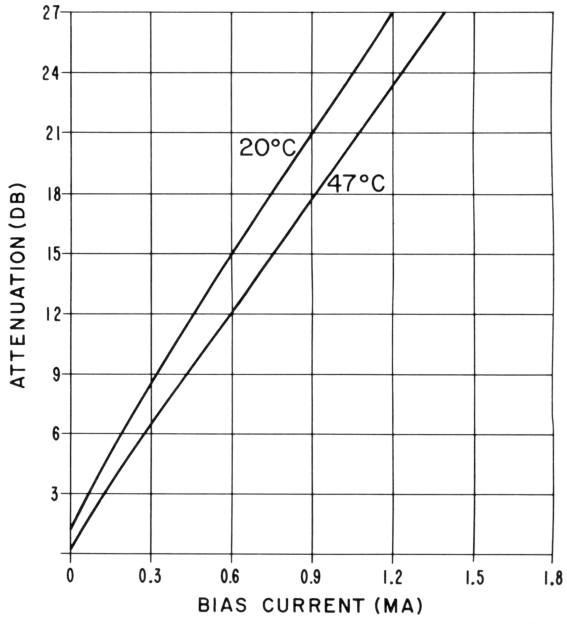




Figure 8. Typical Attenuation Variation at two Different Ambient Temperatures

volts DC) at the BIAS input, at least rated attenuation is provided at all points across the frequency band (i.e., for "A" models at least 35 dB and for "B" models at least 80 dB). The DC current at a negative voltage is forward-bias and typically is about 3 to 5 mA for "A" models and 6 to 7 mA for "B" models. By varying the forward bias current between the stamped value and zero, any level below maximum rated attenuation can be established.

## 25. CLOSED LOOP LEVELING.

26. The PIN Modulator can be used in a closed loop leveling system as the power limiting device for maintaining RF power levels constant. A simplified block diagram of a closed loop leveling system employing a PIN modulator is shown in Figure 9. The system consists of some sampling device which samples the main line RF power level; a detecting device provides a DC signal proportional to the sampled signal; some comparison device which compares the detected signal to what it should be when main line power is at its lowest point and then provides a bias current sufficient to increase PIN Modulator attenuation and maintain a constant RF power level.

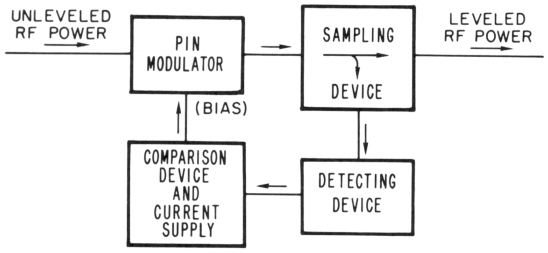



Figure 9. Simplified Block Diagram of a Closed Loop Leveling System

27. LEVELING CAPABILITY. In a closed-loop leveling system involving a PIN Modulator, leveling capability depends entirely upon loop equipment. Hence, loop equipment should be selected on the basis of main line RF power levels and leveling requirements. In the closed-loop system shown in Figure 10 the flatness of leveling is determined primarily by the coupling variation of the directional coupler used. The Power Meter is used because it provides extra loop gain. In addition, with output coupling known, the main line output power can be read directly on the Power Meter allowing for coupling variation. The Leveler Amplifier used has a 0 to -27 Vdc output capability with output impedance of about 20K ohms, hence the 20K ohms series resistor makes it a bias current source providing a maximum 1.35 mA DC current (referring to Figure 5, this means that the maximum control range possible using an "A" model 8730 is between 12 and 20 dB depending upon the individual 8730 used). Typically, with the Power Meter and Leveler Amplifier combination, leveled power can be held constant with ±0.2 dB (plus coupler variation) for RF swept frequency rates equal to or longer than 30 seconds/octave. In practice, slowest swept frequency

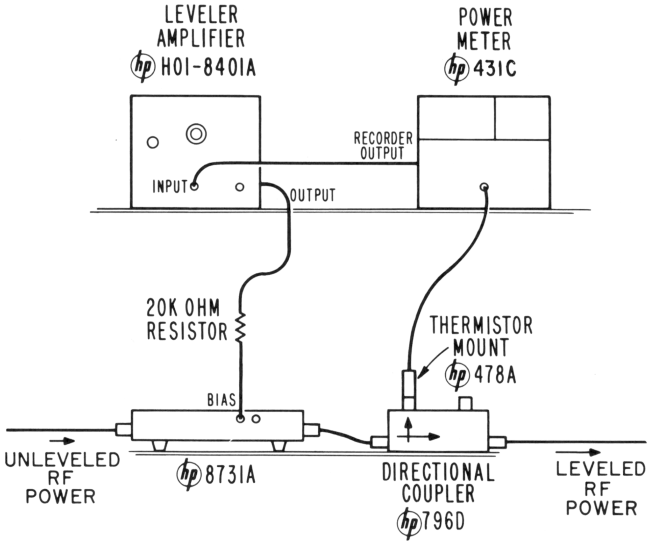



Figure 10. Typical Closed Loop Leveling System

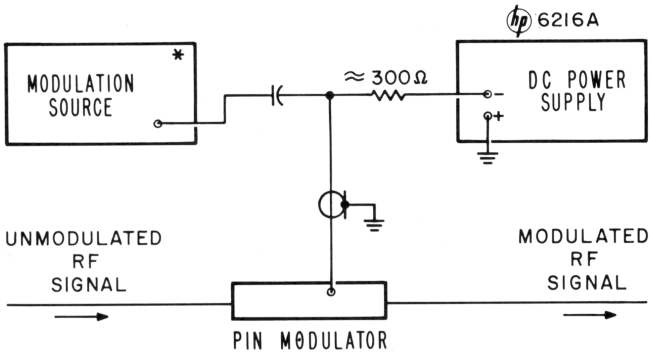
rates always produce the best leveling. However, to determine whether or not any system is leveling properly an Oscilloscope should be used.

28. For faster leveled swept frequency rates, neagtive output detector and directional coupler combinations such as the hp Model 786D and 787D Directional Detectors can be used instead of the Power Meter and Thermistor Mount combination described above. Typically, for the Directional Detector and Leveler Amplifier combination, leveled power can be held constant with ±0.2 dB (plus frequency response of Directional Detector). Note: the frequency response of the Directional Detector includes coupling variation and RF response of the crystal. For the Model 786D (0.96 to 2.11 GHz) this is ±0.2 dB.

## 29. AMPLITUDE MODULATION.

30. The PIN Modulator can be used to amplitude-modulate the RF signal with almost any time-varying signal. Modulation is accomplished with a DC bias current to obtain a specific attenuation level and then superimposing a time varying current upon the bias current. The specific attenuation level upon which the modulating signal is superimposed must be equal to or greater than the peak amplitude of the modulating signal or peak clipping will occur. A control instrument designed for use in modulating applications with the PIN Modulators is the hp Model 8403A Modulator which provides frequency compensation for extending the PIN Modulator AM frequency responseto 10 MHz. However, a typical setup for modulating applications, without the use of the hp Model 8403A Modulator, is illustrated in Figure 11.

31. MODULATION DISTORTION. When a PIN Modulator is used in an AM system, some envelope distortion occurs. This distortion is a function of the peak attenuation and total attenuation range covered by the modulating signal. To minimize RF envelope distortion, the reference level upon which the modu-




*FOR PULSE MODULATION: MODEL 211A, 212A, 214A, 215A
FOR AMPLITUDE MODULATION: MODEL 208A, 651A

Figure 11. Typical General Modulation Setup

lating signal is superimposed should always be a minimum (i.e., reference level should be set at a point only slightly greater than the peak modulating signal amplitude). Under these conditons, a 50% sinusoidal modulating signal (9.5 dB total swing) will result in less than 6.1% distortion. A plot of measured AM distortion for a typical PIN Modulator is shown in Figure 12. Note: AM distortion was measured under the optimum conditons described above. Since distortion, as described here, is a function of the nonlinear sensitivity relationship (shown in Figure 5), shaping circuits may be incorporated to limit overall distortion. Such a shaping circuit is shown in Figure 13.

32. AMPLITUDE MODULATION LIMITATION. In any AM system the modulating equipment limits RF modulating capabilities almost entirely. For example, the power supply and modulation signal source must both be capable of supplying sufficient current to the low impedance 8730 BIAS input. See Figure 5 for typical currents necessary for desired attenuation levels. In addition, the PIN Modulator itself limits the total percent of modulation obtainable. With 35 dB attenuation, AM percent of modulation is limited to a maximum of about 96.5%; with 80 dB attenuation the percent of modulation is for all practical purposes 100%.

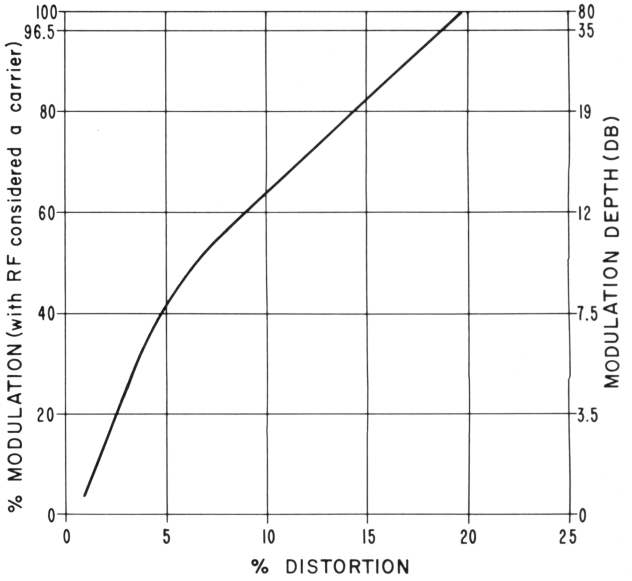
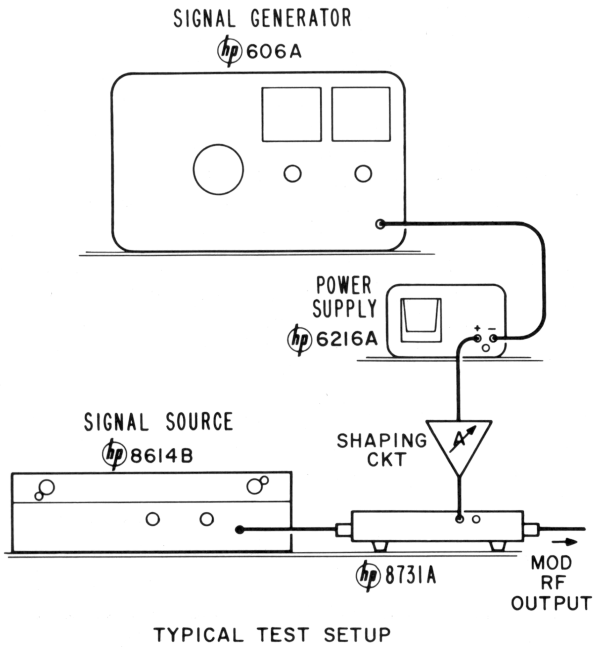
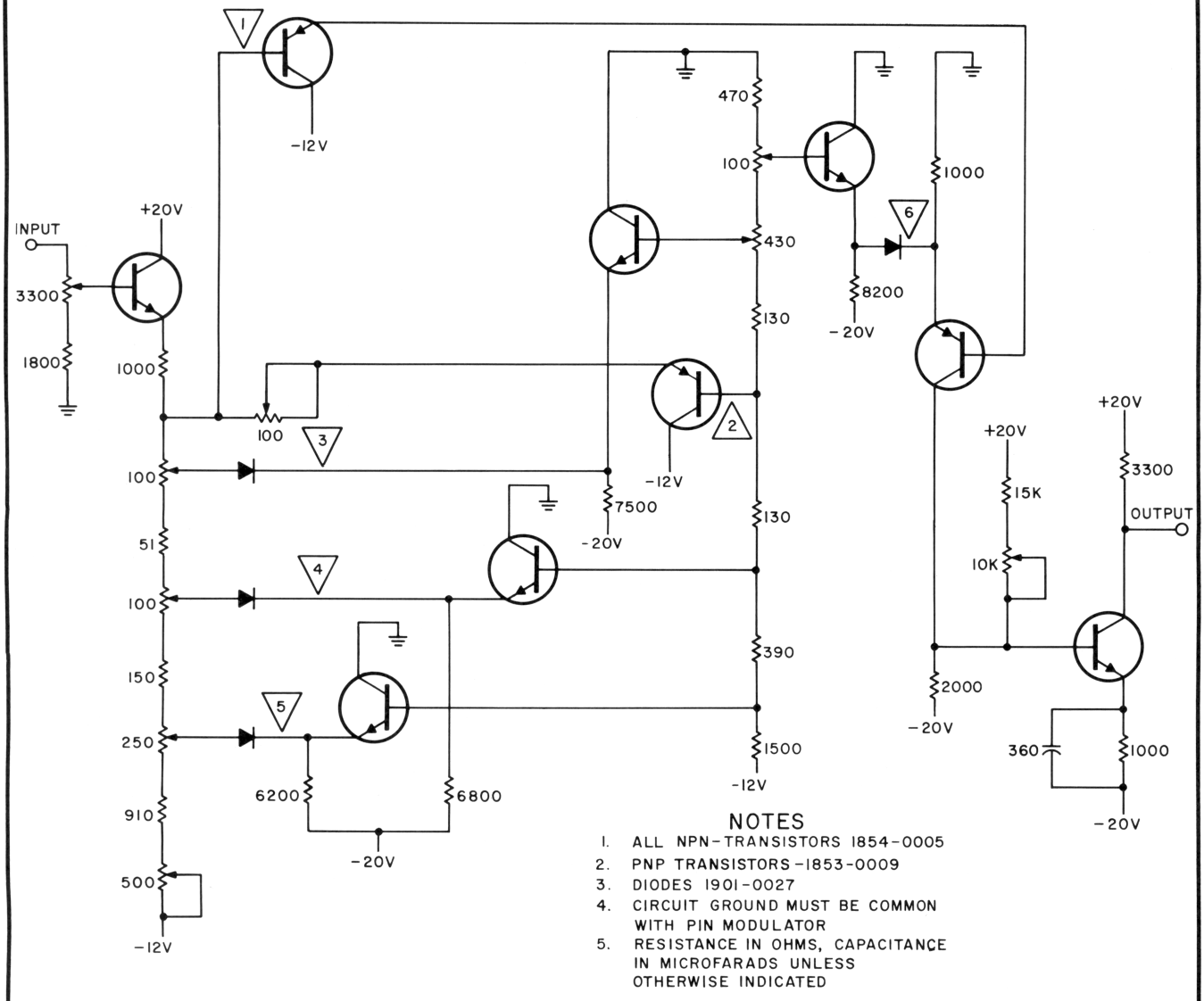



Figure 12. Typical AM Distortion




| INPUT VOLTAGE | TEST POINT VOLTAGES (DC) | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 10VDC | -3.30 | -3.63 / -4.36 | -3.8 / -4.5 | -4.8 / -5.5 | -6.5 / -7.0 | |
| 5.4VDC | -3.59 | -3.75 / -4.41 | -3.98 / -4.6 | -4.9 / -5.6 | -6.5 / -7.0 | |
| 3.0VDC | -3.92 | -4.04 / -4.42 | -4.2 / -4.6 | -5.0 / -5.6 | -6.6 / -7.0 | |
| 1.65VDC | -4.28 | -4.38 / -4.43 | -4.5 / -4.6 | -5.3 / -5.6 | -6.7 / -7.0 | |
| 0.85VDC | -4.63 | -4.72 / -4.44 | -4.9 / -4.6 | -5.5 / -5.6 | -6.9 / -7.0 | -2.7 / -3.1 |
| 0.5VDC | | | | | | -2.7 / -3.3 |
| ⏚ | -4.94 | -5.03 / -4.45 | -5.18 / -4.51 | -5.8 / -5.5 | -7.2 / -6.9 | -2.7 / -3.5 |

Figure 13A. Typical Test Setup (see Figure 13B)




1. The circuit illustrated above will typically meet the following performance features:

   (a) The DC transfer characteristic is within 2% or so of linear at 1.5 GHz. Since the PIN Modulator attenuation bias current characteristic varies widely.

   (b) The bandwidth of the circuit is limited to about 4 Mc (Modulating Signal Frequency).

   (c) Total harmonic distortion should be greater than 20 dB down.

   (d) For proper circuit operation, it is necessary to have an 8-volt signal on the base of the input transistor (8 volts positive and reference to ground).

2. Circuit Adjustment.

   (a) The circuit must be adjusted with the PIN Modulator that it is to be used with and at the RF signal frequency of interest.

   (b) To adjust, apply DC voltage to the input and adjust the appropriate potentiometer in the divider stick as indicated for the "initial setup voltages" (see Figure 13A).

   Note

   To properly adjust the divider stick, start by applying ground to the input and going positive.

   (c) For final adjustment, observe RF output signal and adjust circuit for optimum operation.

Figure 13B. Typical Shaping Circuit

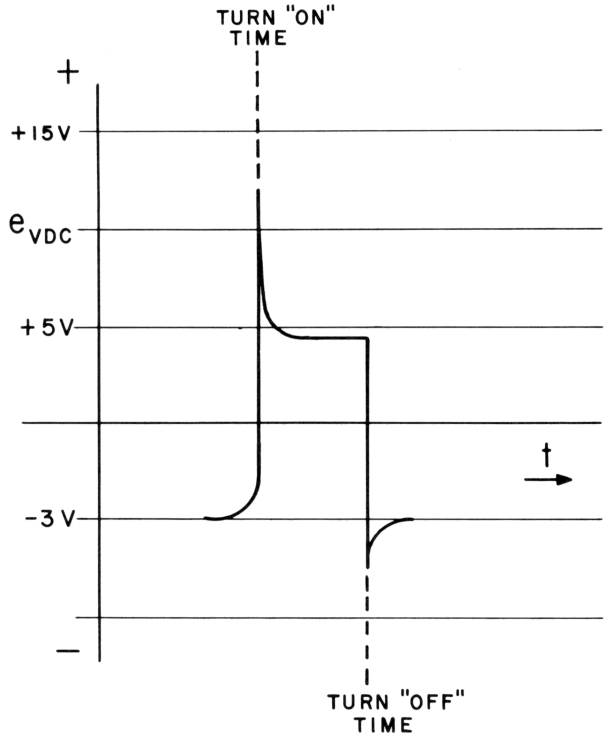



Figure 14. Dynamic Bias Switching Waveform

## 33. PULSE MODULATION.

34. The PIN Modulator can be used as a pulsing or switching device for RF power levels. Modulation is accomplished by applying rated forward bias (see label attached to underside of PIN Modulator) for a maximum attenuation. Once maximum attenuation level is established, the RF power may be pulsed "on" by applying a constant +5 to 6 volts to the BIAS input (voltage must be referenced to PIN Modulator ground). At the end of desired pulse width, the +5 to 6 volt DC potential must be switched to a -0.8 volt level with rated bias current so that RF power level is pulsed "off".

35. To obtain pulsing with rise and fall times in the order of 15 to 40 nanoseconds, the PIN Modulator must be biased with the HP Model 8403A or from a specially shaped impulse waveform such as is illustrated in Figure 14. However, if rise and fall times in the order of 100 to 300 nanoseconds are satisfactory, a setup such as is shown in Figure 11 may be used. Note: in any modulating system, modulating capability depends upon the modulating waveform at the BIAS input connector. Hence, lead lengths should be as short as possible to avoid capacitive cable effects.

## 36. SIGNAL SEPARATION (GATING).

37. Figures 15 and 16, respectively, illustrate use of the PIN Modulator as an RF gating device for eliminating spurious or "ghost" signals in antenna range receivers (Figure 15) or multiple signal separation in a spectrum analysis system (Figure 16).

## 38. MULTIPLE FUNCTION.

39. For certain applications, it may be desirable to level and amplitude modulate a given RF power level with the same PIN Modulator. This can be accomplished by simply setting up a closed loop leveling system and adjusting the reference attenuation level to a point equal to the peak amplitude of the desired modulating signal. For this type of dual application the modulating signal can be applied directly to the leveler amplifier in the system shown in Figure 10.

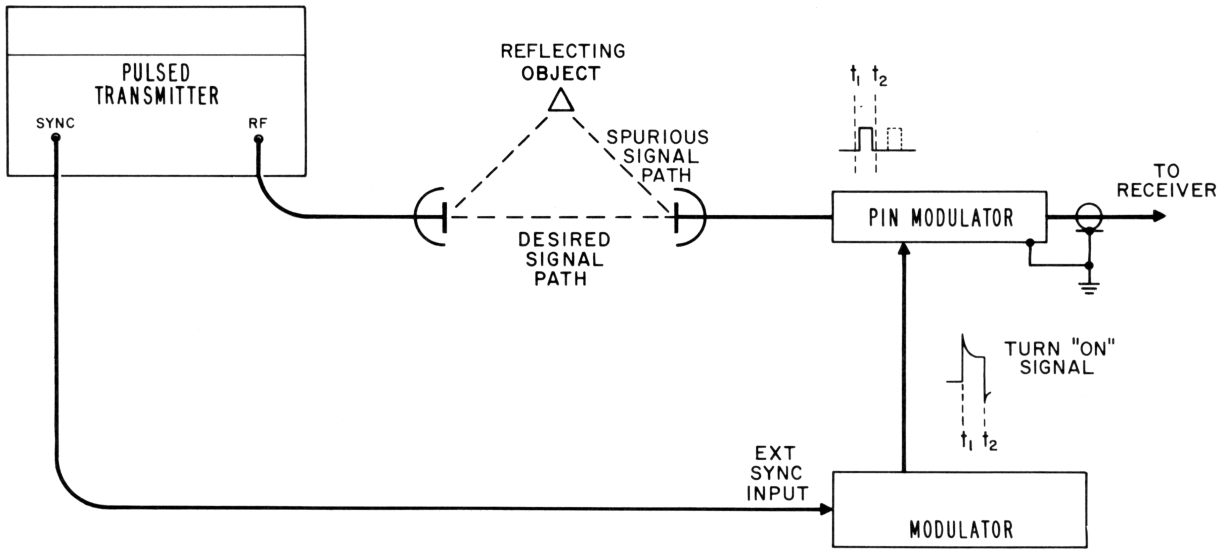
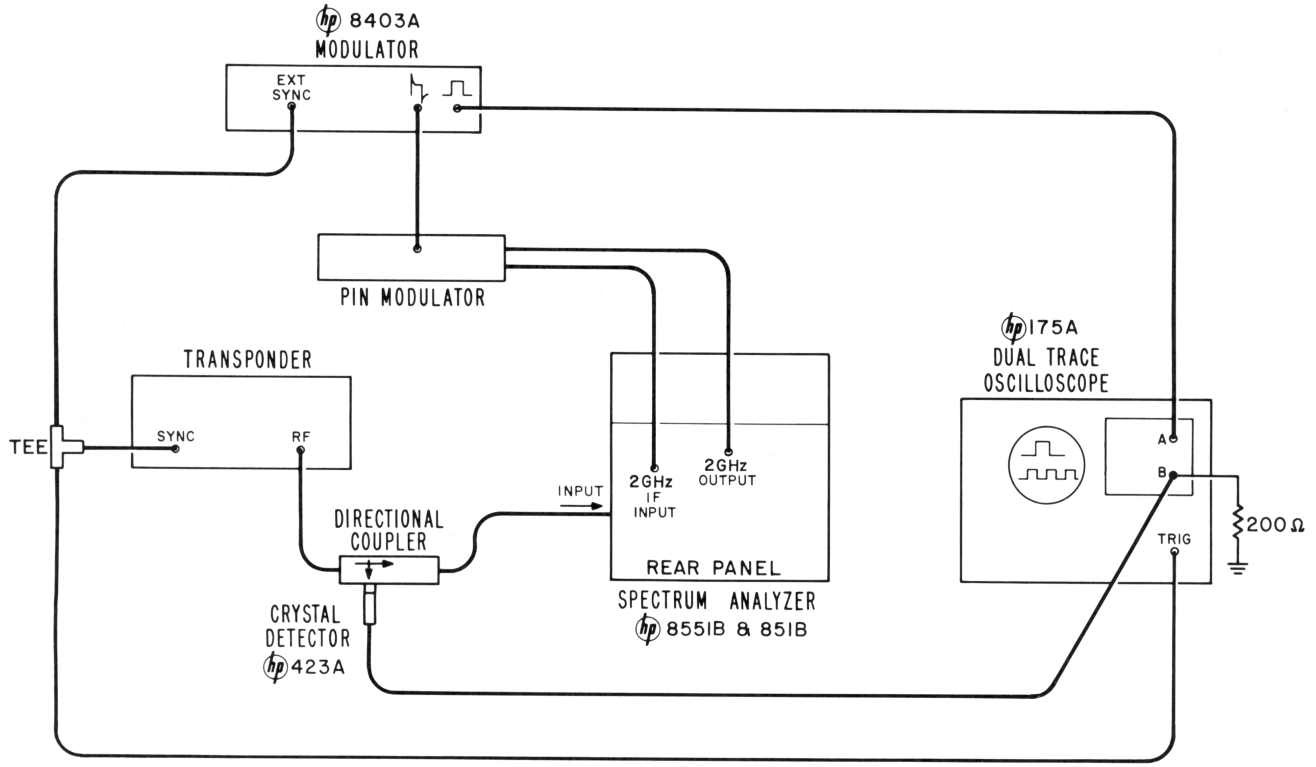



Figure 15. Typical Use of PIN Modulator as an RF Gating Device




In the above setup, the PIN Modulator is used to attenuate all pulse inputs in multiple train except the one of interest. Using the DELAY control on the hp Model 8403A Modulator and noting the Oscilloscope presentation, you can see which pulse is not being blanked. The PIN Modulator is placed in the Spectrum Analyzer 2 GHz-IF path so that the frequency of the RF input need never affect the PIN Modulator. For this setup either a Model 8731B or a Model 8732B may be used since they both cover the 2 GHz frequency range of the IF path.

Figure 16. Multiple Signal Separation for Spectrum Analysis

## 40. MAINTENANCE.

41. PIN MODULATOR REMOVAL AND REPLACEMENT.

42. The PIN modulator CANNOT be repaired in the field. If the PIN modulator is found to be faulty, it should be returned to the factory. Remove the four screws holding the PIN modulator only. Removal of screws holding the PIN diodes in place can cause contamination of PIN diodes, high SWR, etc.

a. Remove power line from instrument.

b. Remove top and bottom covers.

c. Place instrument on its side (preferably the PIN modulator side).

d. Remove retainer rings at RF POWER INPUT and OUTPUT connectors.

e. Disconnect coaxial cable from PIN modulator at J105.

f. Remove four screws holding PIN modulator to instrument chassis (located on top side of instrument).

g. Remove PIN modulator from instrument.

h. Carefully pack PIN modulator in a container and contact local HP field office.

i. To replace PIN modulator, reverse the above procedure.

43. BIAS INPUT CHECK AND REPAIR.

44. If any part of the bias input assembly (Figure 19) is damaged, it can be replaced separately. However, it is good practice to replace the entire assembly. To check bias input assembly, remove the PIN Modulator and measure its resistance with an ohmmeter: straight through the filter resistance should be less than 5 ohms; resistance between BNC center conductor and shell should be infinite.

45. PERFORMANCE CHECK.

46. PURPOSE. The procedure detailed in Table 2 checks PIN Modulator performance for incoming inspection, periodic evaluation, and troubleshooting. The tests are performed without access to the PIN Modulator interior, there is no need to remove PIN MODULATOR for performance checks. The specifications of Table 1 are the performance standards.

47. CHECKING DESICCANT.

48. Inspect desiccant regularly (Figure 17) and, if it is pink or red in color, either remove and dry it or replace it.

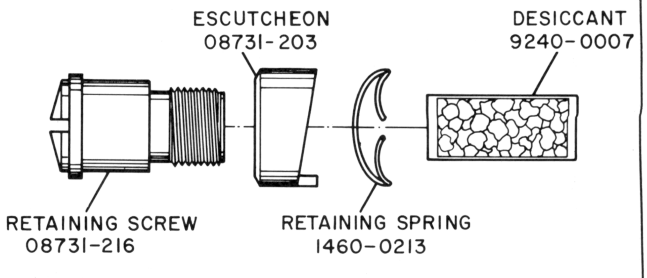



Figure 17. Desiccant Assembly

NOTE: Desiccant only found on 8731-5B: 815-models.

49. TEST EQUIPMENT REQUIRED. The test equipment required to make the performance tests are listed in Table 3. Instruments and accessories other than the ones listed may be used provided their performance equals or exceeds the Critical Specifications.

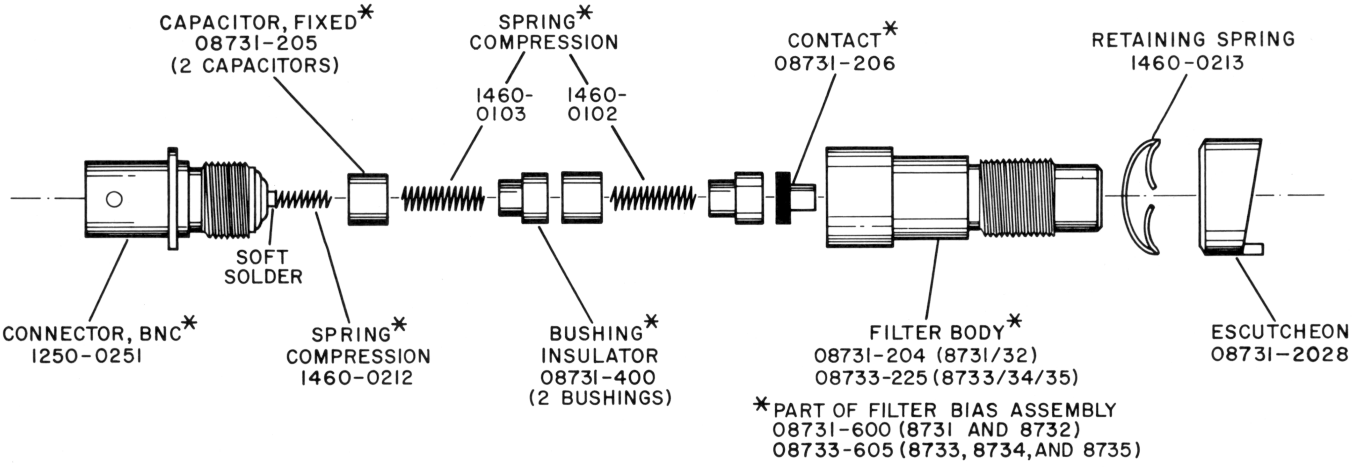



Figure 18. Bias Input Assembly

Table 2. Performance Check Procedure

1. LEAKAGE CURRENT. When back-biased less than 50 μA for "A" models and less than 100 μA for "B" models (see Note 4).

| PROCEDURE | TEST RESULTS (see Note 1) |
|---|---|
| a. Apply +20 volts DC (referenced to PIN Modulator ground) to the BIAS input through a 100K 10% 1/4 W resistor.<br>b. Using a DC voltmeter, measure voltage across resistor. For "A" models less than 5 V (less than 10 V for "B" models).<br>c. If leakage current is excessive, the cause is either a defective BIAS input filter (see Paragraph 43) or internal damage. | Date _____<br>PIN Mod Serial No. _____<br>Measured DC Voltage _____<br>Voltmeter used _____ |

COMMENTS (if any) _____

_____

2. DYNAMIC RANGE (DB). For "A" models (ONLY) at 35 dB across frequency range

| PROCEDURE | TEST RESULTS (see Note 1) |
|---|---|
| a. With a 5 V DC applied to BIAS input, attach a 30-dB attenuator to PIN Modulator RF output.<br>b. Using a Power Meter, adjust RF power source for a near full scale reference.<br>c. Turn off Power Supply and reconnect to PIN Modulator as shown on next page. Adjust Power Supply for rated current (stamped on label attached to underside of PIN Modulator).<br>d. Remove 30-dB attenuator and measure attenuated RF power level: it should be at least 5 dB lower than original reference setting. | Date _____<br>PIN Mod Serial No. _____<br>Attenuation _____<br>frequency _____<br>Power Meter used _____<br>Measure forward bias current _____ |

COMMENTS (if any) _____

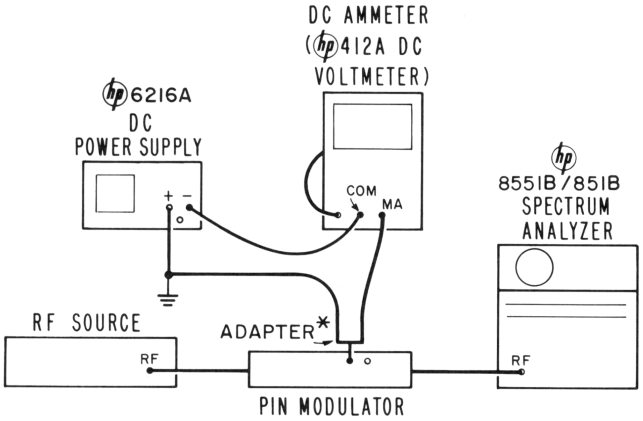
_____

3. DYNAMIC RANGE (DB). For "B" models (ONLY) at least 80 dB.

| PROCEDURE | TEST RESULTS (see Note 1) |
|---|---|
| a. Set Spectrum Analyzer INPUT ATTENUATOR to 60 dB and connect test equipment (NOT INCLUDING THE DC POWER SUPPLY OR DC AMMETER) as shown beneath step c.<br>CAUTION<br>For testing the 8733B, 8734B, or 8735B a TWT Amplifier must be used as part of the RF Source. Be careful not to apply more than 1 W of RF power to PIN Modulator.<br>b. Apply +5 V DC (referenced in PIN Modulator ground) to BIAS input. | Date _____<br>PIN Mod Serial No. _____<br>Attenuation _____<br>frequency _____<br>Attenuator used _____<br>Measured forward bias current _____ |

Table 2. Performance Check Procedure (cont'd)

c. Set Spectrum Analyzer vertical display switch for logarithmic display. Adjust RF Source and Spectrum Analyzer for a convenient deflection reference on analyzer display.




*BNC-TO-BANANA POST ADAPTER hp 10110A

d. Turn off DC Power Supply and connect with DC Ammeter as shown below.

e. Turn on DC Power Supply and adjust for rated current (stamped on underside of PIN Modulator).

f. Decrease Spectrum Analyzer INPUT ATTENUATOR and increase IF GAIN controls for a total increase in sensitivity of 80 dB (i.e., decreasing the INPUT ATTENUATOR from 60 to 30 dB and increasing the IF GAIN control from 20 to 70 dB is a total increase in sensitivity of 80 dB). Specification: input signal deflection must be less than reference of step c.

CAUTION

If 1 watt of RF power is being applied, the Spectrum Analyzer ATTENUATOR must set to 60 dB in step c.

COMMENTS (if any) _____

_____

4. SWR. When back-biased less than

1.5:1 - 8731A & 8732A
1.6:1 - 8731B
1.6:1
2.0:1 - 8732B (see Note 2)
1.8:1 - 8733A & 8734A
2.0:1 - 8733B & 8734B
1.7:1 - 8735A
1.9:1 - 8735B

PROCEDURE

a. With a +5 volt DC (referenced to PIN Modulator ground) applied to BIAS input measure SWR at each end of the specified PIN Modulator frequency range and optionally at any other points of interest.

b. If SWR is excessive, remove PIN Modulator from setup and clean RF end-ports of any dirt or other foreign matter. Repeat SWR measurements.

TEST RESULTS (see Note 1)

Date _____

PIN Mod Serial No. _____

SWR _____ at a frequency of _____

Table 2. Performance Check Procedure (cont'd)

COMMENTS (if any) _____

_____

5. SWR. When forward-biased less than

1.8:1 - 8731A & 8732A
2.0:1 - 8731B & 8732B
2.0:1 - 8733A & 8734A
2.0:1 - 8735A
2.2:1 - 8733B & 8734B
2.2:1 - 8735B

| PROCEDURE | TEST RESULTS (see Note 1) |
|---|---|
| a. With a DC voltage of about -0.8 volts and rated current (stamped on label - underside) applied to BIAS input, measure SWR at ends of specified frequency range.<br>b. If SWR is excessive clean RF input and output connectors and recheck. | Date _____<br>PIN Mod Serial No. _____<br>SWR _____ at a frequency of _____<br>Measured forward bias current _____ |

COMMENTS (if any) _____

_____

6. MINIMUM INSERTION LOSS (DB). When back-biased less than:

1.5 dB - 8731A
3.0 dB - 8733B
4.0 dB - 8734A & 8735A
2.0 dB - 8731B, 8732A, 8733A
3.5 dB & 4.0 dB - 8732B (see Note 3)
5.0 dB - 8734B & 8735B

| PROCEDURE | TEST RESULTS (see Note 1) |
|---|---|
| a. With +5 volts DC applied to BIAS input, measure insertion loss at high end of frequency band and all other points of interest. | Date _____<br>PIN Mod Serial No. _____<br>Insertion Loss _____ at a frequency of _____ |

COMMENTS (if any) _____

_____

NOTES

1. The test results column provided opposite each test procedure is not provided to allow a complete test record but rather to allow test result comparisons for a specific PIN Modulator measured under the same conditions at different time intervals.
2. When back-biased the SWR of the 8732B should be less than 1.6:1 for RF frequencies between 1.8 and 4.0 GHz and less than 2.0:1 between 4.0 and 4.5 GHz.
3. Minimum insertion loss for the 8732B is less than 3.5 dB for RF frequencies between 1.8 and 4.0 GHz and less than 4.0 dB between 4.0 and 4.5 GHz.
4. The leakage current although not an actual specification is the only method of checking diodes for leakage and general condition.
5. To check rise and decay times a Sampling Oscilloscope such as the hp Model 185B should be used.
6. Typical Forward Bias Input Resistance may be calculated by applying 3 or 4 milliammeters of DC current at a negative potential, measuring the negative potential. Specification: For "A" model PIN Modulators, approximately 300 ohms ±100 ohms; For "B" model PIN Modulators, approximately 100 ohms ±50 ohms.

Table 3. Recommended Test Equipment

| Instrument Type | Critical Specifications | Check | Recommended Model |
|---|---|---|---|
| | Equipment For All Models | | |
| DC Power Supply | Outputs: ±0.2 to 20 Vdc<br>±0.5 to 10 mA<br>Impedance: 100 Ω | All | HP 6216A |
| DC Voltmeter and DC Ammeter | Voltage Range: ±3 to 20 Vdc<br>Current Range: 0.5 to 10 mA<br>Accuracy: ±3% | All | HP 412A or HP 410C |
| SWR Meter and Crystal Detector | Freq: of PIN Modulator, Modulated at 1000 Hz ±2% rate<br>Calibration: Square Law<br>Freq Resp: ±0.5 dB<br>Accuracy: ±1% | Minimum Insertion Loss | HP 415E (Meter) and HP 423A (Det.) |
| Resistor | 100K Ω 1/4 W 10% | Leakage Current | - - |
| RF Source | Freq: of PIN Modulator<br>Residual FM: <50 KHz<br>Power Out: 3 mW | All (except leakage current) | 8614B (8731)<br>8616B (8732)<br>8690B (H01-8693B)<br>8690B (H01-8694B)<br>694B (8735) |
| | Equipment For "A" Models Only | | |
| RF Attenuator | Freq: of PIN Modulator<br>Atten: 30 dB<br>Accuracy: ±2 dB | Dynamic Range | Weinschel 210-30 (all coaxial models)<br>HP X382A (8735A) |
| Power Meter | Power: up to 10 mW<br>Freq: of PIN Modulator<br>Instrument Accuracy: ±3%<br>Calibration: mW and DB | Dynamic Range | HP 431B or HP 432A (Meter)<br>HP 478A (Mount 8731A thru 34A)<br>HP X486A* (Mount 8734A/ 8735A) |
| | Equipment For "B" Models Only | | |
| Power Meter | Freq: of PIN Modulator<br>Power: up to 2 W<br>Accuracy: ±6% | Dynamic Range | HP 434A |
| Spectrum Analyzer | Freq: of PIN Modulator<br>Calibration: logarithmic in DB/cm<br>Sensitivity: -90 dBm (-65 dBm for 8733B/34B/35B) | Dynamic Range | HP 851B (display section) and HP 8551B (RF Section) |
| Microwave Amplifier | Freq Range: of 8733B/34B/ or 35B<br>Power Out: 1 W from 1 mW input | Dymanic Range | HP 491C (8733B)<br>HP 493A (8733B)<br>HP 495A (8734B and 8735B) |

* Note: For use with 8734A, an X281A Coaxial to waveguide and a male-to-male type N adapter must be used

# APPENDIX III

BACKDATING

# MANUAL CHANGES

MODEL SERIES 8730A/B
PIN MODULATORS

Make all backdating corrections in this manual according to changes below.

| SERIAL PREFIX OR NUMBER | MAKE MANUAL CHANGES | SERIAL PREFIX OR NUMBER | MAKE MANUAL CHANGES |
|---|---|---|---|
| 8731-5B: 815- | A, B | | |
| 8732A: 816- | B | | |
| | | | |
| | | | |

CHANGE A:

Paragraph 41 and 42:
Add desiccant, stock no. 9240-0007; Escutcheon, stock no. 08731-203; Desiccant retaining screw, 08731-216.

Change bias input escutcheon stock no. 08731-2028 to 08731-203.

CHANGE B:

Table 1; SWR specification:
Change SWR specification from "1.8, 1.8 to 4.0 GHz: 2.0, 4.0 to 4.5 GHz" to "1.8, 1.8 to 4.5 GHz".

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